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ERRATA FOR VOLUME V

Page 150 line 2, for rötkliche read röthliche.
Page 150 line 7, for ohnlich read ähnlich.
Page 153 line 1, for Sphaecelotheca read Sphacelotheca.
Page 186 line 2, for *Zizania aquatica* L. & *Z. palustris* L., read *Zizania aquatica* L. and *Z. palustris* L.
Page 217 line 22, omit trouble.
Page 283 line 8, for Pathologist read Physiologist.
Pages 244 and 289, for Franklin Lincoln Stevens read Frank Lincoln Stevens.
Pages 263 and 264, interchange legends for figures 2 and 3.
In explanation of Plate XVI, fig. 2, for synnemata read synnema.
Page 326, interchange legends for Plates XV and XVI.
Page 349 line 13, for Atroplex read Atriplex.

ROBERT HARTIG

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ROBERT HARTIG

(1839–1901)

E. P. MEINECKE

WITH PORTRAIT, PLATE I

In our era of specialization, that curse and blessing of modern research, we look up, with amazement and admiration, to those universally trained men of by-gone generations, who, as well trained in speculative philosophy as in all branches of scientific endeavor, were capable of producing as thorough work in botany as in mathematics, in entomology as in astronomy. Leonardo da Vinci and Goethe, artists, poets, philosophers and scientists at the same time, are types impossible in our days. The times of a Humboldt, Schleiden or Darwin have passed forever. The second half of the last century has brought that splitting up of disciplines into innumerable, everbranching specialties, which has resulted in unheard-of triumphs of research on one side and in the most short-sighted narrowness of conception on the other. *Robert Hartig* and his contemporaries, as a type, form the connecting link between the old and the modern school. Born in 1839 (Brunswick, Germany, May 30) he grew up in the ideals of universality. Throughout his work in later life, highly specialized though it was, these ideals saved him from losing sight of the really big issues, from mistaking digging for creation. Discipline of mind, the result of the thorough and broad, often even pedantic, schooling which formed an integral part of the pedagogic system of the period, preserved him from superficiality.

Robert Hartig was the last issue of a family of scientists. His grandfather, Georg Ludwig Hartig, chief forester of Prussia, laid the scientific foundations of modern silviculture. Georg Ludwig's son, Theodor Hartig, one of the great foresters of his times, well known through his work on the theory of yield, is known in botany by his discovery of aleuron and his writings on a great number of botanical subjects.

In this atmosphere of research Robert Hartig grew up. Family tradition and early training brought him in touch with the scientific problems of his period and laid that broad foundation of solid knowledge and clear understanding which served him so well in later life.

Robert Hartig received his college training at the University of Berlin. In 1864 he entered the Brunswick Government Service. The routine and narrowness of mind which he encountered there were not to his taste. He soon resigned his position to go back to University work. He took his doctor's degree at Marburg and went into forestry work. In the midst of this activity he was sent to the Forest Academy at Eberswalde, where he was to lecture during the illness of Professor Ratzeburg. Inside of four days he began with his customary energy, though quite unprepared, his lectures on Botany and Zoology.

This step was decisive for the further course of his life. From that time on his activities were devoted to University teaching and research. From 1866 to 1878 Hartig taught at Eberswalde. Although deeply interested in zoological problems, he soon turned to Botany, particularly to questions with a strong bearing on forestry. Some of his most important works were written at Eberswalde. His "Wichtige Krankheiten der Waldbäume" and "Zersetzungserscheinungen des Holzes der Nadelholzbäume und der Eiche" are fundamental. In 1878 he was called to Munich, Bavaria, as Professor of Botany and Head of the Botanical Department of the recently founded Royal Forestry Experiment Station, where he remained to the end of his life. The intellectual atmosphere of Munich and the liberal attitude of the Bavarian Government in contrast to the stricter tone of Eberswalde made him feel at home at once in the Bavarian capital. A period of intense and fruitful work began, only to end with his death. In regular succession a stream of books and papers poured from his laboratory, each one a masterpiece in itself, each one a distinct and valuable gain to science. Hartig was as little free from error as any great man; but even where he erred in detail, his lucid and thorough discussion invariably brought new light to his subject by that wonderful faculty of seeing beyond the "thing in itself." To him *Fomes annosus* or *Dasyscypha willkommii* were not merely new forms of fungi he happened to discover; to him they were living organisms in close relation to other living organisms. Biology and ecology in our modern sense were not terms used in Hartig's earlier days, but Hartig was both a true biologist and an accomplished ecologist.

In his "Wichtige Krankheiten der Waldbäume," his "Zersetzungserscheinungen des Holzes der Nadelholzbäume und der Eiche" and papers from the "Untersuchungen aus dem forstbotanischen Institut I, II, III" Robert Hartig has laid the foundations of modern Forest Pathology.

Numerous later papers and books, particularly his "Lehrbuch der Baumkrankheiten," later "Lehrbuch der Pflanzenkrankheiten" (translated into English, French and Russian) brought an almost overwhelming amount of knowledge on the subject. His work is synonymous with Forest Pathology. None of his contemporaries has ever approached his fertility in this line; no man since has brought any fundamentally new concepts into this branch of science.

Although undoubtedly the father of modern Forest Pathology and, therefore, one of the most important contributors to phytopathology in general, Robert Hartig stands out as one of the most ingenious investigators in other lines of pure and applied botany as well. His contributions to our understanding of the mechanics of sap movement, of the activity of the cambium, of the mechanics of annual increment in trees, of the formation of spring- and summerwood, of the rôle of reserve material in the life of the tree have become common knowledge to such an extent that they form part of every textbook on botany.

Another side of his astoundingly many-sided lifework was devoted to problems in forestry. It would be out of place here to go into detail. In Forestry Robert Hartig is given the same rank as his father and grandfather. In younger years he has also done remarkably exact work in Entomology, especially on forest insects.

Besides the books already mentioned, Robert Hartig has given us twelve separate publications and about one hundred and fifty papers printed in periodicals, particularly in Tubeuf's Forstlich-Naturwissenschaftliche Zeitschrift, in the Botanische Zeitung and in forestry periodicals.

His influence on younger men has been an unusually strong one. A teacher of uncommon qualities, ever ready with advice, kind-hearted, inspiring, a strong personality, he has shaped hundreds of young foresters and botanists from all parts of the world and has had the good fortune to see a rich harvest spring up from the seed he has sown. In the midst of the most active work he died on October 9, 1901.

Robert Hartig, the scientist and teacher, the indefatigable worker, has built his own monument in the world of thought; but another image, that of Robert Hartig as the prototype of manly character and genuinely human qualities, lives forever in those who have been fortunate enough to know him in person.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY
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THE LIFE HISTORY OF ASCOCHYTA ON SOME LEGUMINOUS PLANTS. II[1]

R. E. Stone

With One Figure in the Text

In a previous publication, the life history of *Ascochyta pisi* Lib. and *Ascochyta lethalis* Ellis and Barth. was given in some detail.[2] It was then shown that *A. pisi* Lib. was connected with *Mycosphaerella pinodes* (Berk. and Blox.) Stone on the pea and also that the same fungus occurs on *Vicia sativa* and *Vicia villosa* and was capable of infecting *Lathyrus odoratus*. It was also shown that *A. lethalis* Ellis and Barth. was a part of the life cycle of *Mycosphaerella lethalis* Stone. Subsequent publications by other authors have borne out these conclusions at least in regard to *Ascochyta pisi* Lib.[3, 4]

In September, 1912, while looking for material of *Mycosphaerella pinodes*, a small plot of *Lathyrus sativus* (grass pea) was found infected with an Ascochyta having somewhat the appearance of *Ascochyta pisi* except that the pycnidia were smaller as were also the spores which were frequently without a septum. Since the work on *Ascochyta pisi* was still being carried on, careful watch was kept of the plot in order, if possible, to secure a Mycosphaerella or other Ascomycete which might be associated with this imperfect form on the grass pea.

In a few weeks an examination of the plants showed a Mycosphaerella to be present in considerable quantity. Since the fungus differed in some respects from *Mycosphaerella pinodes*, cultures were made from it for the purpose of determining its life history and its relation to the similar fungus occurring on the garden pea and vetches.

IDENTITY OF THE FUNGUS ON LATHYRUS SATIVUS L.

In Saccardo, Sylloge Fungorum, two species of Ascochyta are given as occurring on species of Lathyrus. *A. lathyri* Trail on *Lathyrus silvestris* and *A. orobi* Sacc. on *Lathyrus (Orobus) vernus*, etc. but none is recorded on *Lathyrus sativus*.

[1] Contributions from the Botanical Laboratory, Ontario Agricultural College.

[2] Stone, R. E. Ann. Myc. **10**: 564. 1912.

[3] Melhus, J. E. Phytopathology **3**: 51. 1913.

[4] Vaughan, R. E. Phytopathology **3**: 71. 1913.

The Ascochyta collected here differs very much from *A. orobi* Sacc.[5] in having much smaller spores. *A. orobi* has spores 15 to 16μ by 4.5 to 6μ, while the one collected here has spores 8 to 12μ by 2.5 to 3μ often without septa. It agrees closely with *A. lathyri* Trail[6] as far as spore measurements are concerned, but, when it occurs on leaves, it frequently causes distinct spots as well as lesions on the green stems and pods. It has been shown that *A. pisi* may infect *Lathyrus odoratus*,[7] but the fungus cannot be considered a form of *A. pisi* for the reason that repeated attempts at infection of *Pisum sativum* have given negative results and also the behavior in culture as well as the perfect stage do not agree with the fungus on the garden pea.

The species of Sphaerella listed as occurring on the genus Lathyrus are: *Sphaerella nemorosa* Sacc. et Speg., *S. nerviseda* Speg., *S. nerviseda* var. *microspora* Sacc., *S. melaena* (Fr.) Awd.,[8] *S. lathyri* (A. Pot.) Sacc. et Trav.,[9] and *S. pinodes* (Berk. et Blox.) Niesl.[10]

Sphaerella melaena (Fr.) Awd. as described by Ellis[11] has yellowish spores, a character absent from the fungus according to Schroeter[12] and Winter.[13] *S. melaena* (Fr.) Awd. is not a true Sphaerella but belongs in the genus Ascospora, a genus characterized by a subiculum and one celled ascospores.

Sphaerella nerviseda Sacc. et Speg. is characterized by slender spores 15 to 20μ by 2.5 to 3μ, quite different from the one under consideration.

Sphaerella Lathyri (A. Pot.) Sacc. et Trav. has larger perithecia, larger asci, and larger ascospores than the one found here.

It can not be considered a form of *S. pinodes* as the spores are smaller, it behaves very differently in culture and does not infect *Pisum sativum*.

The fungus agrees fairly well with *S. Nemorosa* Sacc. et Speg., but the ascospore stage has been found so far only on dead and dry leaves, stems, and pods and is not directly responsible for the formation of leaf spots.

It agrees very closely with *Sphaerella nerviseda* var. *microspora* Sacc. in the size of the spores and their arrangement in the ascus, but the spores are a little wider as is also the ascus. *S. nerviseda* var. *microspora* is given as occurring on dead foliage of *Orobus vernus* and associated with a Septoria and *Phyllosticta orobella*.[14] The fungus collected here occurs

[5] Sacc. Syll. Fung. **3**: 398.
[6] Sacc. Syll. Fung. **10**: 303.
[7] Stone. Ann. Myc. **10**: 579. 1912.
[8] Sacc. Syll. Fung. **1**: 504 and 513.
[9] Sacc. Syll. Fung. **22**: 128.
[10] Stone, R. E. Ann. Myc. **10**: 579. 1912.
[11] Ellis. North American Pyrenomycetes.
[12] Schroeter, Cohn. Kryptogamen flora.
[13] Winter, Rabenhorst Kryptogamen flora.
[14] Sacc. Syll. **9**: 615.

on dead leaves, stems, and pods of *Lathyrus sativus* and is associated with an Ascochyta whose immature spore might well be taken for a Phyllosticta. The fungus occurring here is sufficiently different from the ones already described to warrant its consideration as a new species.

In proposing a name, one is somewhat at a loss to know just what generic name to use. If we consider Sphaerella as a *nomen conservandum* then it should be called Sphaerella.[15] If we follow the usage of Schroeter,[16] Lindau,[17] Rehm, and others, the proper generic name would be Mycosphaerella, while, if we follow the suggestion of Wollenweber,[18] the name Pycnosphaerella should be used, since the perfect stage is connected with Sphaerioidiaceous conidial stage.

Mycosphaerella is here used to agree with the author's previous use of the name.[19]

Mycosphaerella ontarioensis sp. nov.

Perithciis 50 — 100μ x 70μ; erumpentibus subsuperficialibus, globoso-papilliatis; osteolo brevis et pertusis; asci oblongo-cylindiacei, sessilis vel breviter stipitato, apice poroso, 45 — 50μ x 12 — 14μ; Sporidiis hyalinis 10 — 12.5μ x 5 — 6μ, medio septatis, lenter constrictis, apice acutis, cellulae 2-guttulatis; oblique monostichis.

In foliis, caulibus et fructibus emortuis Lathyri sativi. September — March, Guelph, Ontario. Socii spermagoniis Ascochyta.

Maculis epiphyllis, caulibus et fructibus, sordidis-brunneo, marginatis vel obscuris. Pycnidiis sparsis; lenticularibus, erumperitis 75 — 160μ; brunneis pseudo-parenchymatis; Sporulis copiosis, cylindricis 8 — 12.5μ x 2.5 — 3μ, mox 1, septatis non constrictis vel continuis.

In foliis, caulibus et fructibus, languidis et emortuis, Lathyri sativi. June — October, Guelph, Ontario.

Type specimen and cotype material deposited in Herbarium of New York Botanical Garden.

Collections.

Ascochyta: Guelph, Ontario, September 15, 1912, October 20, 1912, July, August, 1913.

Mycosphaerella: Guelph, Ontario, October 20, 1912, November 1, 1912, September, 1913.

Part of the collection of September, 1913, was kept out doors and examined at intervals until March, 1914. Asci and ascospores could be found at any time and the spores were in a viable condition until March or later.

[15] Sacc. Syll. **22**: 128.

[16] Schroeter, Cohn. Kryptogamen flora. Pilze.

[17] Lindau, Engler und Prantl. Die Natürliche Pflanzenfamilien.

[18] Wollenweber. Phytopathology **3**: 229. 1913.

[19] Stone. Ann. Myc. **10**: 521. 1912.

It is probable that the specimens collected by Ellis at New Field, New Jersey, 1890, on the "Everlasting Pea" and labelled by him *Sphaerella melaena* (Fr.) Awd., and which was provisionally transferred to *Mycosphaerella pinodes*,[20] belong here as the characters of the asci and ascospores agree perfectly with the *M. ontarioensis*.

In working out the life history of *Mycosphaerella ontarioensis*, the same general plan was used as was employed in working with *M. pinodes* and *M. lethalis*.

CULTURES

October 21, 1912. Ten single ascospores were planted in bean decoction agar. Eight of these germinated and from each a colony of Ascochyta developed. The colonies were first visible in four days. At first they were white with a little aerial mycelium, but after ten days the colonies began to take on a brown color due to numerous chlamydospore-like cells. The chlamydospores were globose 15 to 20μ in diameter with walls 2 to 3μ thick and occurred in chains of 2 to 5. The chlamydospores were capable of germinating as shown in the figure. The colonies were slow to develop pycnidia, but after twenty-one days brown pycnidia containing typical pycnidiospores were formed.

November 6, 1913. Ten single ascospores were planted in nutrient bean agar. Seven of these germinated and gave rise to colonies as described in the first experiment.

January 8, 1914. Sixteen ascospores were planted in nutrient agar and of these thirteen germinated and gave rise to Ascochyta colonies with chlamydospores and pycnidia as previously described.

The presence of chalmydospores is a character which gives the colonies in culture much the appearance of *A. lethalis*,[21] but the chlamydospores are much more numerous than in that species and the colonies are darker. In this respect they differ very much from *A. pisi*.

Ascospores were not obtained in cultures.

INFECTION EXPERIMENTS

Infection experiments were not tried in 1912 as there were no green plants obtainable which were suitable for the work.

November 26, 1913. Ten plants of *Lathyrus sativus* were sprayed with Ascochyta spores obtained from the cultures planted November 6, 1913. Eight of these plants developed typical lesions on the stems and leaves which bore pycnidia and spores. The pycnidia were mature on December 20, 1913.

[20] Stone, R. E. Ann. Myc. **10**: 579. 1912.

[21] Stone, loc. cit.

These same plants were allowed to grow under normal greenhouse conditions and finally the infected leaves and stems died and became dry. In February, 1914, these dead and dry leaves and stems began to bear perithecia which were typical of the Mycosphaerella from which the Ascochyta cultures were obtained.

January 26, 1914. Four plants were inoculated with Ascochyta material obtained from ascospores planted January 8, 1914. All of these

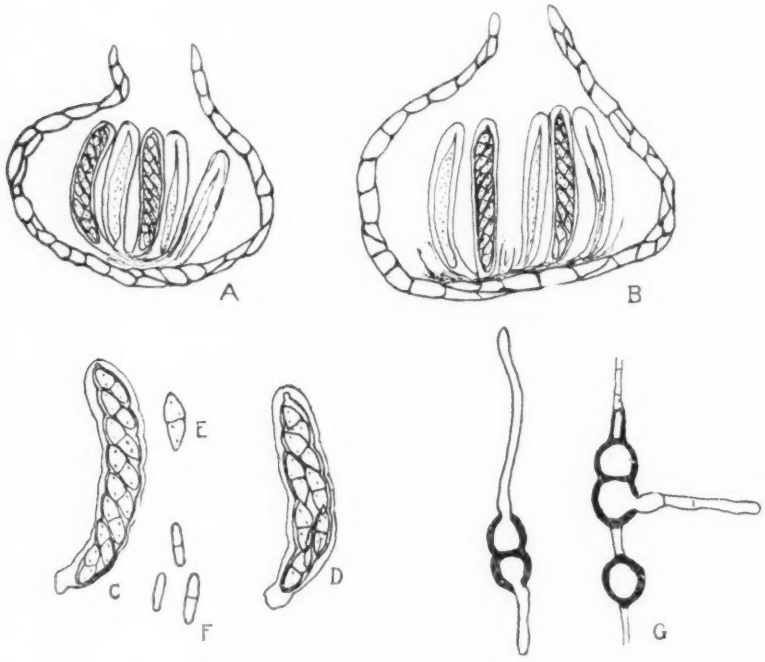

FIG. 1. *A* and *B*, longtitudinal sections of typical perithecia of Mycosphaerella ontarioensis, × 350; *C*, ascus of the same developed in a greenhouse, on plants inoculated with Ascochyta, × 500; *D*, ascus of the same developed in the field, × 500; *E*, a typical ascospore, × 500; *F*, pycnidiospores, × 500; *G*, chlamydospores developed in culture germinating, × 500.

plants developed Ascochyta and by May 1, 1914, perithecia with typical ascospores were developed on the dry parts of the diseased plants.

March 1, 1914. Two plants were enclosed in moist chambers with old stems and pods bearing viable ascospores. These plants developed the typical Ascochyta and by May 15 dry stems and leaves were developing typical perithecia and asci of *Mycosphaerella ontarioensis*.

In all cases the check plants remained free from the disease.

CONCLUSIONS

The grass pea (*Lathyrus sativus* L.) in this locality acts as the hosts for an Ascochyta resembling *A. Lathyri*. Later the same plants bear an Ascomycete closely related to *Sphaerella nerviseda* var. *microspora* Sacc. which is here named *Mycosphaerella ontarioensis*. The Mycosphaerella and the Ascochyta are stages in the life history of the same organism.

1. The Mycosphaerella follows the Ascochyta in the field.

2. The ascospores when planted in nutrient agar give rise to an ascochyta which is capable of infecting the host plant.

3. The infected areas develop typical Ascochyta like the plants in the field, and later these same diseased areas develop a Mycosphaerella indistinguishable from the original material.

4. Plants inoculated with ascospores directly develop first the typical Ascochyta and later the Mycosphaerella.

5. In all cases the check plants remained free from the disease.

CONDITIONS FOR ASCOSPORE DEVELOPMENT IN MYCOSPHAERELLA PINODES AND MYCOSPHAERELLA ONTARIOENSIS

In many cases of ascomycetes which have a parasitic conidial stage, the imperfect form is found during the growing season on the living parts of the plants, while the perfect stage appearing the following spring is found on the dead leaves, twigs, fruits and so forth on the ground, i.e. *Venturia pomi*, *Mycosphaerella fragariae*, *Guignardia bidwellii*, etc.

It occasioned some surprise, therefore, when work was begun on *Mycosphaerella pinodes* to find the perfect stage as early as July and August of the same season and on the same material which had developed the conidial stage. Often the two stages were intermingled. The condition is the same whether *M. pinodes* occurs on the pea or vetch. The same conditions hold for *M. lethalis* on the sweet clover and *M. ontarioensis* on the grass pea.

In the previous work done on *M. pinodes*, the ascospore stage was not obtained[22] but Vaughan[23] in his work states that in one experiment he obtained ascospores on his inoculated plants in the greenhouse. He gives no details of the work, however.

While the present work on *Mycosphaerella ontarioensis* was being carried on further, work on *M. pinodes* was carried along with it. As ascospores were developed with both fungi some idea of the conditions for their development was obtained.

[22] Stone, loc. cit.

[23] Vaughan, R. E. Phytopathology **3**: 71. 1913.

MYCOSPHAERELLA PINODES

February 10, 1913. Ten pea plants were inoculated with a pure culture of Ascochyta obtained from the ascospores. By March 3 the pycnidial stage had passed its prime and the plants were beginning to wither. By April 1, the plants were all dead, but they were watered as usual. May 21, perithecia with ascospores were mature.

November 14, 1913. A number of pea plants were similarly inoculated and the plants treated in a similar manner. By March 24, 1914, the ascospore stage had appeared.

In the first case the ascospore stage appeared in a little over 3 months from the time of inoculation and after a period of six weeks of purely saprophytic existence at the ordinary greenhouse temperature. In the other case four months elapsed, but the plants had remained green longer so that the saprophytic existence was for about the same length of time.

MYCOSPHAERELLA ONTARIOENSIS

By referring to the experiments previously cited in this paper we can see what is the rule for the present fungus.

Inoculation	*Ascospores obtained*
November 20, 1913.	February, 1914.
January 26, 1914.	April 27, 1914.
March 1, 1914.	May 15, 1914.

In these cases the time between inoculation and the formation of the perfect stage was two and one-half to three months. Here perithecia developed on dead and dry leaves still attached to green stems and on dead and dry stems themselves.

In these cases the plants were kept growing in an ordinary greenhouse along with the conservatory plants, etc.

If we examine conditions in the field, we will see that under normal conditions these fungi develop their imperfect and perfect stages under similar temperature and biological conditions. In fact the ascospores are most easily obtained in August and September after several days of dry weather. These fungi develop their perfect stage after a period of one or two months of saprophytic existence at a temperature of 60 to 70° F. or even higher.

It would seem from these instances that our idea that the Sphaeriales, having a parasitic conidial stage, require the variations of temperature and factors attendant on a winter season in order to develop their perfect stage, is not well founded. It would be worth while to experiment with other forms in order to throw more light on this little understood question.

ONTARIO AGRICULTURAL COLLEGE

THE TEMPERATURE RELATIONS OF SOME FUNGI CAUSING STORAGE ROTS

ADELINE AMES

This investigation was undertaken with a view of getting some exact data on the thermal relations of a few of the fungi causing storage rots. The growth of some of these fungi at lower temperatures has been investigated in a general way in refrigerating experiments, but the more detailed work has been limited to a few of the common saprophytes.

H. Hoffmann[1] in 1860, experimenting with several fungi among which were *Trichothecium roseum*, *Fusarium heterosporium*, *Penicillium glaucum* and *Botrytis vulgaris*, found that they germinated very near the freezing point and that they did not lose their vitality at a temperature below freezing, although such a temperature was fatal to germinating spores.

Wiesner[2] found the maximum and minimum temperatures for the germination of the spores of *Penicillium glaucum* to be 43°C. and 1.5°C., for the development of the mycelium 40°C. and 2.5°C. and for the formation of spores 40°C. and 3°C.

Tiraboschi[3] found that *Penicillium glaucum* did not germinate at 37°C. and maintained at that temperature for a month completely lost its power of germination.[4] Thiele working with the same species determined the maximum temperature for germination to be between 30° and 35°C. He experimented with several strains and found that the same species grown on different media or media of different concentration had a different maximum temperature. The discrepancies in the results of the temperature limits of *Penicillium glaucum* as determined by these different workers might have been due to incorrect identification of the species as well as to variation in physical or biological factors.

[1] Hoffman, Hermann. Untersuchungen über die Keimung der Pilzsporen. Jahrb. f. wissensch. Bot. (Pringsheim) **2**: 267–297. 1860.

[2] Wiesner, Julius. Untersuchungen über den einfluss der Temperatur auf die Entwicklung des Penicillium glaucum. Sitzber K. Akad. Wiss. (Vienna) Math. Naturw Kl. **68**: 5–16. 1874.

[3] Tiraboschi, C. Attenuazione del potere germinativo delle spore di Penicillium glaucum mantenuto a 37°C. Rivista pellagrologica **8**: 1–16. 1908. For abstract see Centralb f. Bakt Abt 2. **22**: 463. 1909.

[4] Thiele, R. Temperaturgrenzen der Schimmelpilze. Leipsiger Dissertation. 1896.

Istvánffy[5] found that the spores of Monilia, Botrytis, and Coniothyrium did not germinate above 39°C. to 41°C. Exposure to freezing temperature for a week destroyed a large percentage of the spores. Spores kept dry for some months were more sensitive to cold than those from fresh cultures.

Ewert[6] investigated the so-called summer or conidial stages of some of the ascomycetes which are supposed to be carried through the winter only in the perithecia. The conidia of *Mycosphaerella sentina* subjected alternately to artificial cold as low as −16°C. and thawing temperatures germinated as readily as untreated conidia. A small percentage of the conidia of *Pseudopeziza ribes* left over winter where the temperature went to −22°C. germinated in the spring. *Fusicladium pyrinum* and *F. dendriticum* were used to represent tests on hyphomycetous fungi. After several exposures to temperatures below freezing, they did not germinate as readily as untreated spores. The author concluded that resistance to cold did not depend on the protection afforded by the pycnidium but was due to qualities innate within the protoplasm.

Eustace[7] among others, conducted some cold storage experiments on fruits inoculated with rot producing fungi. Apples were inoculated with Penicillium, *Glomerella rufomaculans*, *Sphaeropsis malorum*, and *Cephalothecium roseum* and placed in cold storage for two months. Penicillium produced a small rotted area at 1°C., but the other fungi grew only a small amount even at 8°C. At 26°C. the fruits inoculated with *Cephalothecium roseum* and Alternaia showed rotted spots, those with Glomerella were partially decayed and those with *Penicillium glaucum* entirely rotted. Peaches inoculated with *Monilia fructigena* after two weeks at 0°C. showed small rotted spots.

From the results of these different workers, the difficulties of eliminating all factors other than temperature are readily seen. The strain and peculiarities of the individual species of fungus, its previous habitat, its age, the conditions of moisture, the nutritive qualities of the media on which it is to be grown and the time factor in relation to temperature, all must be considered.

The fungi selected for this work were *Glomerella rufomaculans* (Berk.) Sp. & von Sch. and *Cephalothecium roseum* Corda from apples. *Thiela-*

[5] Istvanffy, Gy. A Botrytis, Monilia ès Coniothyrium sporáinak életkép ességéröl mathematikai ès termèszettudománys estesatö. A. M. T. Akademia 3 osztà lyàn ak folyóirata **21**: 222–235. For abstract see über die Lebensfahigkeit der Botrytis, Monilia and Coniothyrium Sporen. Centralbl. f. Bakt Abt. 2. **11**: 584–586. 1904.

[6] Ewert, Dr. Die Uberwinterung von Sommerkonidien pathogener Ascomyceten und die Widerstandsfähigkeit derselben gegen Kälte. Zeitschr. f. Pflanzenkr. **22**: 129–141. 1910.

[7] Eustace, H. J. Investigations on some fruit diseases. N. Y. Agr. Exp. Sta. Bul. 297: 31–48. 1908.

viopsis paradoxa (de Seyn) Höhn. from pineapple, *Penicillium digitatum* (Fr.) Sacc. from orange, *Rhizopus nigricans* Ehrenb. from sweet potato and *Monilia fructigena* Pers. from plums. The strains used came from cultures isolated directly from the rotting hosts. String bean infusion (1 part by weight of beans to 2 parts of water), titrating plus 8 on the Fuller scale with $1\frac{1}{2}$ per cent agar-agar added was the medium selected for the stock cultures. All of the fungi grew luxuriantly on it. They were grown at what seemed to be their optimum temperature for growth, determined in a few preliminary experiments. Care was used in maintaining a constant temperature, as other workers have found that the temperature at which a mycelium develops influences the time required for the germination of its spores (Wiesner).

The experiment was divided into three parts: (1) The maximum and minimum temperatures for spore germination were determined and the time required for germination at different temperatures. (2) The amount of growth and fruiting at various temperatures. (3) The thermal death-point of spores exposed in a given solution to the heat of a water bath for a given period.

Germination tests. Dilutions in bean agar were made by transfers from slant bean agar cultures fruiting abundantly and not older than ten days. Van Tieghem cell drop cultures were employed and immediately after making were placed in the thermostats.

For the higher temperatures the cultures were grown in thermostats heated with gas burners and provided with a water jacket and a Roux thermo-regulator; for the lower temperatures the ice thermostat manufactured by Paul Altmann was used. It has compartments in which temperatures from 1°C. to 20°C. can be maintained. No thermostat for temperatures below 1°C. were available. Variations greater than 1° in an individual compartment were not experienced during fairly uniform weather temperatures.

The time at which germination began was noted. No attempt was made to determine the percentage of germination as no great difference was noted between the various cultures and the checks except in cultures at the extreme upper and lower limits of germination. The spores of most of the fungi germinated uniformly well. *Cephalothecium roseum*, however, showed great variability, often only a few spores out of several score in a drop would germinate. This could in no way be connected with its temperature relations but was rather due to a lack of vitality on the part of the fungus itself. Table 1 gives the time in hours required for germination.

Monilia and Penicillium only germinated at 1°C., but the spores of the other fungi, after remaining in the cool compartments several weeks with-

out germination, when brought to a higher temperature, germinated. Germination was much delayed, and the percentage of spores germinating was much smaller than when the culture was placed under favorable conditions.

Cultures left in the incubator thirty-six hours at a temperature a degree above the maximum temperature for germination did not germinate when removed to an optimum temperature. One or two spores in a few excep-

TABLE 1

Time in hours required for germination of the spores

TEMP.	THIELAVIOPSIS PARADOXA	RHIZOPUS NIGRICANS	MONILIA FRUCTIGENA	PENICILLIUM DIGITATUM	GLOMERELLA RUFOMACULANS	CEPHALOTHECIUM ROSEUM
deg.						
1	None	None	245	120	None	None
3–4	None	200	144	90	200	None
5–6	168	168	100	48	174	None
9–10	45	51	24	32	39	96
10–12	23	43	7	15	15	24
15	13	36	7	8	8	15
17	8	16	7	8	7.5	9
19	8	16	7	8	7	7
20	8	16	7	8	7	7
25	8	13	7	8	7	7
28	8	12	7	8	7	7
30	8	10	7	8	7	7
32	7	8	7	8	7	7
33	7	8	7	None	7	7
35	6	6	7	2 spores out of many	7	7 (a few spores out many)
36	6	6	7		7	None killed
37.5	None	6	None		None	
38		5½				
39		5½				
41		5½				
42		None				
43		Killed				

tional cultures germinated but in most of the drops they seemed no longer viable. No systematic attempt was made to determine the period of heat rigor which the spores could endure and remain alive, although from the few general observations made it seemed much shorter than given by some workers for fungus spores. Helbrig[8] for example found that some fungi were able to endure a long period of heat rigor. *Penicillium glaucum*

[8] Helbrig. Ueber den Einfluss supramaximaler Temperatur auf das Wachstum der Pflanzen. Leipziger Dissertation. 1900.

remained alive after an exposure of fifty-one days at one degree above the maximum temperature for germination.

The effect of the lower temperature was to retard germination, of the higher to destroy the cell. In a graphic representation of the period for germination in relation to the temperature, we would have a gradual downward movement of the curve until a temperature near the optimum is reached where it would remain nearly level to the maximum. In Penicillium a retardation due to the heat could be detected but in none of the other fungi. Penicillium spores germinated within eight hours at the optimum temperatures for growth. At 32°C. which is very near the maximum, a few of the spores germinated within eight hours and many after twenty-four hours. It may be that the spores germinating only after delay at the maximum temperature would not have germinated earlier if grown at an optimum temperature, although no such variation was observed in the tests made at this temperature. The spores of the remaining fungi germinated within as short a period at the maximum temperature as at the optimum and, at a degree above, would not germinate even if left for a longer period. No doubt if the incubators could have been regulated sufficiently accurately a point of delayed germination due to heat could have been located.

It was found that different strains of the same species sometimes have slightly different temperature limits. In the early part of the experiment a strain of Monilia obtained from peach was used. Its maximum temperature for germination was 30°C. The culture of this was lost and the work was repeated with a strain isolated from plums. The germination of the two strains at the lower temperatures approximately agreed, but the maximum temperature for growth of the second was 36°C.

Growth and fruiting experiments. In determining the amount of growth and fruiting at various temperatures one series of cultures was made on slant bean agar and placed immediately in the temperature compartments. Another series, made in Petri dish poured plates after germination at 25°C., was placed in the compartments.

Table 2 gives the data from the observations on these cultures. The fungi in general show the same temperature relations as in the germination experiments. Monilia and Penicillium are most resistant to cold and Rhizopus best adapted to higher temperatures. Monilia differed from the other species in thatalthough the spores germinated at 35°C. no further growth occurred at that temperature and even at 30°C. the mycelial colony was limited in size.

Constant temperatures below 1°C. could not be maintained but that the fungi are not killed by lower temperatures was found in testing the viability of cultures left out of doors exposed to the winter temperature at

TABLE 2

Amount of growth at various temperatures

TEMPERATURE	THIELAVIOPSIS ETHECETICUS	MONILIA FRUCTIGENA	RHIZOPUS NIGRICANS	GLOMERELLA RUFOMACULANS	CEPHALOTHECIUM ROSEUM	PENICILLIUM GLAUCUM
degree						
1–2	No growth	No growth	No growth	No growth	No growth	Small colonies in a few cultures
3–4	No growth	Small colonies. No fruiting	No growth	No growth	No growth	Small colonies. No fruiting
9–10	No growth	Good growth. Fruiting within 8 days	Some growth. No mature sporangia after 1 month	Some growth. Conidia within 5 weeks	Small colonies. No fruiting within 1 month	Small colonies. Fruiting within 11 days
10–12	Small colonies. No fruiting within 3 weeks		Good growth. Mature sporangia within 3 weeks	Some growth. Conidia within 3 weeks	Small colonies. No fruiting within 1 month	Good growth. Fruiting within 4 days
14–16	Good growth. Fruiting within 3 days	Good growth. Fruiting within 3 days	Mature sporangia within 6 days	Good growth. Conidia within 8 days	Good growth. Fruiting within 6 days	Good growth. Fruiting within 3 days
17–18	Good growth. Fruiting within 2 days	Heavy growth. Fruiting within 2 days	Mature sporangia within 3 days	Good growth. Conidia within 6 days	Fruiting within 4 days	Heavy growth. Fruiting within 2 days
20–22	Good growth					Maximum growth
25		Maximum growth		Conidia within 4 days	Maximum growth	
30	Maximum growth	Scant growth. Abnormal mycelium and few conidia	Mature sporangia within 2 days	Maximum growth	Small colony. Scant fruiting	Very small white colonies. No fruiting

33	Good growth	No growth	Mature sporangia within 36 hours			Small colonies of abnormal mycelium
35				Scant growth	Scant growth. No fruiting	No growth
36	Scant growth. No fruiting		Maximum growth	Scant growth. No fruiting	No growth	
37	No growth		Good growth	No growth		
40			Good growth			
42			No growth			

Ithaca, New York, where the thermometer registered −16°F. (−27°C.). Spores from these cultures (except *Cephalothecium roseum*) germinated as readily as those of cultures kept at room temperature.

It is seen, as generally conceded, that growth and germination occur at a temperature a few degrees below that at which fruiting takes place. Thus in Thielaviopsis, germination occurs at 5° to 6°C. but there is no fruiting although some growth at 10°C. Some of the Glomerella spores were able to germinate at 4°C., but it required a temperature of 12°C. to produce normal spores. Similar differences are noted at the upper limits. Although Penicillium germinates at 30°C. and forms a small patch of mycelium, no conidia are produced. Thielaviopsis formed a mycelium at 36°C. but no conidia. The mycelium formed under the unfavorable conditions of the upper limits of temperature is not sufficiently vigorous to produce spores while at the lower limit the cold retards their development.

The cultures allowed to germinate at an optimum temperature and then placed in the cool compartments developed a mycelium at a lower temperature than those germinating in the compartments. Early growth under favorable conditions doubtlessly acted as a stimulus to a certain extent for the continuance of growth under unfavorable conditions. Thielaviopsis formed no mycelium at 9°, but cultures germinated outside formed a thin layer of mycelium even at a much lower temperature and microspores at 9°C. Rhizopus at 3° to 5°C. produced considerable mycelium although no growth beyond germination occurred in cultures placed immediately at this temperature. Rhizopus was very erratic in the production of sporangia. In one series of cultures, sporangia were formed at a temperature as low as 10° to 12°C. The tests were repeated some months later and no sporangia were obtained at 20°C. and even at higher temperatures in many of the cultures. The results on spore germination agreed in all the experiments. No reason could be ascertained for this peculiarity in fruiting.

Thermal death-point experiments. The apparatus used in determining the thermal death-points consisted of a water bath heated by a gas burner which was controlled by a thermo-regulator. The water was maintained at a uniform temperature through the motion created by a revolving water wheel. The temperature was read from a thermometer suspended in the water.

Transfers of the spore masses were first made to tubes of distilled water. After the tubes were well shaken to separate the spores in order to avoid discrepancies due to unequal heating, transfers were made from these tubes to tubes containing 10 cc. of bean decoction. They were then exposed in the water bath for ten minutes after which they were removed to an incubator set at 25°C. The figures given in table 3 indicate the lowest temperature at which there was no growth after such treatment or the thermal death point.

The results of the germination tests and thermal death points relative to one another are in accord. Rhizopus, which has spores germinating at a high temperature, has a high thermal death point and Glomerella, Monilia and Thielaviopsis, which have spores germinating at about the same temperature, have like thermal death points. Penicillium shows the greatest difference between the thermal death point and the maximum temperature. The Penicillium spores have a greater tendency to adhere in masses than those of the other species and it may be that the figure given is too high because the spores were not uniformly heated. As stated above, care was taken to avoid this, and the experiment was repeated several times but with like results.

The low thermal death point of Cephalothecium was probably due to the attenuation of the cultures. The thermal death points were determined toward the close of the work and for some time in all of the cultures Cephalothecium had shown a lack of vigor.

TABLE 3

Thermal death points

THIELAVIOPSIS PARADOX	RHIZOPUS NIGRICANS	MONILIA FRUCTIGENA	PENICILLIUM DIGITATUM	GLOMERELLA RUFOMACULANS	CEPHALOTHECIUM ROSEUM
52.5–53°	60–60.5°	52–52.5°	58–58.5°	53–53.5°	47–48°

Summary. The cardinal points of temperatures are within the limits stated in general for fungi by other workers. Monilia and Penicillium germinate at 0°C. but growth is very slow. The other fungi do not develop below 5°C. but if growth is started at a higher temperature, it can continue at this temperature. Aside from Rhizopus none of the organisms is able to germinate above 36°C. The optimum temperature of growth for Monilia and Penicillium is 25°C., Thielaviopsis, Glomerella, and Cephalothecium 30°C., Rhizopus 36°C. The thermal death point of Rhizopus is 60°C., of Penicillium 58°C., and those of the remaining fungi between 51°C. and 53°C.

The results indicate that in refrigerating experiments, temperatures near zero must be maintained if development of rot producing fungi is to be entirely avoided. From the effect of the exposure to low temperatures on the germination of the spores, one can also conclude that the conidial forms of fungi are much more resistant to cold than is commonly supposed.

Acknowledgments are due to Dr. Erwin F. Smith for the use of the ice thermostat in his laboratory and to Misses McCulloch and Hedges for observations made on some of the cultures.

BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

STORM AND DROUTH INJURY TO FOLIAGE OF ORNAMENTAL TREES

CARL HARTLEY AND THEODORE C. MERRILL

WITH THREE FIGURES IN THE TEXT

GENERAL

The season of 1913 was unusually dry and hot in many parts of the country. A number of severe local storms also occurred. In consequence of these conditions inquiries from correspondents had little to do with parasitic leaf trouble, but there was much complaining of injury which could not be definitely traced to parasites. Detailed observations were made in the District of Columbia, and places in Pennsylvania and New Jersey were also studied. In the District the rainfall from March 1 to May 26 was excessive. For June and July, the total rainfall was only 35 per cent of normal while the weather was at the same time very hot. This period was followed on July 30 by a hail storm, heavy rain, and wind of 68 to 70 miles per hour. In August and the first half of September there was little additional rain. Vineland, New Jersey, was without drouth and Montclair, New Jersey, was subjected to a severe drouth in June. The places mentioned furnished favorable opportunity for studying the results of different meteorological conditions.

DROUTH INJURY

In the District of Columbia at least 25 per cent of all Norway maples were noticeably affected. Those surrounded by impervious paving material suffered most. As might naturally be expected well rooted trees in parks and cemeteries resisted the short sharp drouth. Leaf injury was practically all marginal. A typical case of this type of injury is shown in figure 1. Marked cases showed dead tissue extending into the body of the leaf between the veins. Where injury was most serious, practically the entire leaf was killed, and the leaf dropped soon after this extensive damage. Most of the leaves less severely injured than the one figured persisted during the remainder of the season. In some instances a spotted leaf injury, probably due to drouth, affected areas lying in the interior of leaves, with only moderate marginal injury. Sugar maple also exhibited injury both marginal and between the veins, though the proportion of trees affected was much smaller than in the case of Norway. Distribution of

the injury was noticeably localized in many trees, certain branches being nearly defoliated, while others between them were nearly uninjured. This condition was especially marked in sugar maple and indicated considerable differences in the ability of different branches to compete for water. Injury to the leaves was unexpectedly uniform on all sides of the crown

FIG. 1. Norway maple. Shaded area indicates part killed by drouth.

though it was oftenest more severe on the south and southwestern aspects. The age of street trees bore little relation to the amount of injury, Norway maples 2 inches and 10 inches trunk diameter (breast height) being about equally affected. Leaves on the extreme periphery of the crown, not shaded by others, were more injured than those in the interior. Silver maples suffered somewhat from drouth, injury being marginal. Sycamore

maples largely escaped, as did also two other exotic maples *A. palmatum* (Asia) and *A. campestre* (Europe), the two latter being found in parks rather than in street planting. Some American basswoods showed marginal injury. Elm dropped some of its leaves but those remaining were not materially damaged. Horse chestnut in some streets suffered heavily. Injury to leaves not entirely killed was mostly terminal or in fewer cases marginal. Most of the injured street trees were nearly defoliated.

An especially interesting case of drouth injury occurred on pin oak (*Quercus palustris*). During the latter part of August, a ditch 5 or 6 feet deep was opened alongside a row of pin oaks near the United States Treasury, passing within 4 feet of most of the trees, which were about 10 inches in diameter. This ditch cut a number of roots. One of the trees was not more than 2 feet from the ditch, which was allowed to remain open for some time, so that in addition to the cutting of part of the roots, water loss from the soil containing uninjured roots was increased by evaporation through the wall of the ditch. During the first week in September the foliage of several of these trees turned yellow, the greatest injury appearing in the one nearest the ditch. Damage developed rapidly so that the tree nearest the ditch was practically defoliated by the middle of September, when the ditch was filled and the trees were heavily watered. Leaves on this tree died at once all over the tree and fell within a few days after the first symptoms appeared. The few persistent leaves showed typical marginal injury, living leaf tissue remaining along the main veins only (fig. 2). With one exception all trees along this ditch showed marginal leaf injury and partial defoliation, while no trees in the row beyond the end of the ditch were affected. The defoliated tree retained the green cambium of the twigs and showed reasonably healthy buds at the time of the last examination a month later. The leaves of many pin oaks in other parts of the district were yellowish and unhealthy during the latter part of the summer, but only a few had their margins killed by the drouth.

Certain infrequent injury seen in Norway maples may have been parasitic. This injury appeared as unusually light-colored dead blotches or areas of $\frac{1}{4}$ to 1 square inch situated in the leaf interior. Often it was adjacent to the veins. A differential point between this kind of injury and the marginal drouth type is its general occurrence in leaves shaded by location within the crown, while drouth mostly damages leaves situated externally. In Philadelphia, where no serious drouth occurred, this type of injury was more frequent, affecting both Norway and sugar maples. At Vineland, New Jersey, where no serious drouth was reported, this "blotch" type of injury seemed to predominate on both Norway and sugar maple, and silver maple was not injured.

In Montclair, New Jersey, and vicinity the injury was confined mostly to sugar maples and was generally distributed through the crowns of a few trees. It showed no uniform preference for any particular point of the compass in affected trees but appeared mainly in the upper and outer foliage and was generally marginal. Weather reports and the character of the injury indicate drouth as the cause. In Montclair there is much

FIG. 2. Pin oak. Shaded area indicates part killed by drouth.

local interest in trees and considerable attention is devoted to their conservation. Plenty of watering and liberal planting space are provided and as a consequence the trees show the effect of the favorable environment.

Thuja occidentalis showed early browning of older foliage to an unusual extent, other white cedars suffering to a lesser degree. Numerous other species of conifers in the vicinity of Washington were not affected, though

growing close to the injured arbor-vitae, and under the same conditions. Among these were *Thuja orientalis*, *Chamaecyparis lawsoniana*, *Libocedrus decurrens*, *Juniperus virginiana*, *Taxus baccata*, *Taxodium distichum*, *Picea parryana*, *P. excelsa*, *P. orientalis*, *Tsuga canadensis*, *Pinus excelsa*, and *P. strobus*. All the specimens of Taxodium available for comparison were much larger and probably older than the arbor-vitae, which may explain their freedom from injury.

Reports by correspondents show drouth near Knoxville, Tennessee, as evidenced by wilting of leaves of black and white oak and dogwood. Weather Bureau records at Knoxville showed a more serious deficiency in rainfall than at Washington. A great many injured maple leaves on which no parasite could be developed were received from drouth-affected portions of New York and New England. Tip burning of white pine needles was reported from the northeastern states and especially from the Adirondacks. Premature browning of arbor-vitae was seen in Iowa specimens.

From the Holy Cross National Forest in Colorado, Forest Service officers reported damage to reproduction in lodgepole pines over considerable areas. Engelmann spruce and Alpine fir also suffered in the neighborhood of lodgepole stands. The growth of the current season was first injured in all cases. Many small lodgepole saplings were reported as entirely killed. Discoloration of the bark in dead parts of the tree varied from pale green to light brown and, at the base of the dead part, a line of very dark brown inner bark seemingly indicated a parasite, but observations made during previous seasons has shown that this browning of the bark at the base of dead twigs is not uncommon where young growth has been killed by non-parasitic factors. Cultures of such browned bark in moist chamber and on agar in the season of 1909 failed to develop any parasite. On September 4, 1913, similar specimens of injured lodgepoles were furnished by Mr. J. C. Blumer from Macdowell, Saskatchewan. It was stated that some of the injured trees presented an appearance as if fire had run through the tops. In western pines this kind of tip killing shows death of entire twigs at once, whereas, in the sun-scorch type of the eastern white pine blight, death of the terminal parts of the needles commonly takes place before that of the lower parts of the twigs.

The effects on trees of a much more severe drouth than any encountered by the writers was reported from Nebraska by Pool,[1] who found early leaf fall especially prevalent with hackberry, elm, and Carolina poplar, while ash (*Fraxinus lanceolata*) was the least affected. As with defoliated trees at Washington, many completely defoliated trees put out a number of

[1] Pool, Raymond J. Some effects of the drought on vegetation. Science N. S. **38**: 822–825. 1913.

new leaves near the end of the season, and abnormal autumn flowering was more common than at Washington. A number of street trees are reported to have died from the drouth during the summer, a result more serious than was observed in the vicinity of Washington. A more severe drouth than that at Washington is also reported for the summer of 1913 from southeastern Ireland.[2] In this case ash was among those that suffered most, showing a distinct wilting of the foliage even in middle aged trees, but no premature ripening as did other species of trees. Drouth was more easily observed in trees from four to eight years old, and Japanese larch in a six-years-old plantation suffered a large percentage of loss by death due to drouth. European larch and various spruces and pines in these young plantations suffered only to the extent of decreased growth. The drouths in Nebraska and most of the eastern United States, and in Ireland, during this season, were distinctly summer drouths of not over three months' duration, the spring rainfall having been above normal. A very brief drouth is evidently sufficient to cause injury to the leaves of the maples commonly used in street planting, detracting from their appearance but causing no permanent injury. That only street trees or trees recently planted were sufficiently injured to cause death in any of the cases above mentioned is to be expected from drouth of so short duration even with the maximum severity reported from southeastern Nebraska. If the spring had also been dry, injury to all sorts of shade trees might have been expected to follow in the places where summer drouth was most severe. However, the effect of the drouths noted on forest trees in general was so slight that we must expect extensive permanent injury or death of established trees only after successive seasons of severe drouth.

The writers are indebted to Prof. M. F. Ahearn, of the Kansas Agricultural College, for notes on the effects of successive drouths on ornamentals at Manhattan, Kansas. Here the season of 1912 had been dry, so that the soil was dry to an unusual depth at the beginning of 1913. 1913 drouth was very severe in this locality, and the cumulative water deficit resulted in the loss of well established trees of a number of species. *Pinus strobus*, *P. austriaca*, *P. sylvestris*, *Picea canadensis*, *Fraxinus lanceolata*, *Celtis occidentalis*, and *Aesculus glabra* were especially hurt. Arbor-vitae was seriously affected, and the Chinese arbor-vitae, commonly more drouth-resistant than the American, came out little better in this case. Norway maple was relatively uninjured, while red maple was seriously affected, contrary to the writers' experience at Washington.

The white pine blight in New England, on which considerable has been written within the last few years, seems largely due to recurrent drouths.

[2] Forbes, A. C. The effect of summer drouth upon tree growth. Gardeners Chronicle, Third series, **54**: 299. 1913.

The most striking case of drouth injury recently noted,[3] in which a large proportion of death of a dominant species occurred in high forest over considerable areas, was caused by two successive years of extreme drouth.

STORM INJURY

In the District of Columbia injury was noted particularly to sugar maple leaves in connection with the storm mentioned in the first paragraph. Trees showed storm effect on the northeast, from which direction the storm came. Injury was naturally greatest on the more exposed parts of the trees. In trees protected by buildings except as to the top or when the wind current was east to west in well built-up streets running east to west, injury was worse in the extreme tops and on the east, or even on the southeast sides. Blown-in windows on the south side of buildings showed that in certain places the full force of the northeast wind was deflected back toward the north by surrounding buildings. Trees in the suburbs growing under more natural conditions than those in the central part of the city were more exposed and showed correspondingly increased damage, instead of less damage, as in the case of drouth. Many sugar maples of all ages lost most of their leaf surface on the northeast side of the crown. Trees presenting the same exposure to the storm showed considerable differences in the resultant injury. These differences indicated a variable susceptibility or possibly an effect of soil conditions on susceptibility. Practically all exposed sugar maples were injured, most of them seriously enough to hurt their appearance for the remainder of the season, though no permanent effect is anticipated. The trees most exposed lost one-third or one-half of their leaves and a great number of the leaves on the northeast sides of the trees were so badly injured that they dropped within the next few weeks. Red and Norway maple and box elder suffered slightly from the storm, while silver maple was nowhere affected. A few basswood trees were injured very severely. Certain trees 10 to 14 inches in diameter lost all their foliage on the exposed side and in some instances most of the leaves on the opposite side were also killed. A few much-exposed horse chestnuts were also partly defoliated on the northeast side by the storm. Sycamore (mainly *Platanus orientalis*) and elm were generally uninjured. From tulip trees and gingkos, in places of exceptional exposure, such as wind-swept corners, a large proportion of the leaves were torn away during the storm, but the remaining leaves were not harmed. Poplars suffered little damage. American beech, copper beech, *Paulownia imperialis*, and most other trees grown in parks were not seriously injured. The

[3] Troup, R. S. A note on the causes and effects of the drought of 1907 and 1908 on the sal forests of the United Provinces. India Forest Department. Forest Bulletin 22, 17 p., pl. Calcutta. 1913.

native mixed hardwoods in forest and woodland areas escaped noticeable foliage injury, as was also the case with conifers.

Injury to maple leaves by storm presented unexpected resemblance to the injury by drouth. Nearly all of the leaves affected by storm, if examined without inspecting the trees, would have been considered in-

FIG. 3. Sugar maple. Shaded area indicates part killed by storm.

jured by drouth. Only inspection of the trees showing the injury mainly limited to the exposed side could afford a correct diagnosis. Observation was not begun soon enough after the storm to determine the exact appearance of the initial damage. Large areas of the leaves both at the margins and between veins were killed. The location of dead tissue on a typical leaf injured by storm is shown by the shaded portions of figure 3. The

injury to the lobes is most easily explained by the bruising and bending of the edges incident to the leaves whipping against each other and against twigs and branches in the high wind. The tissue between the veins, naturally more subject to bending than other parts, probably owed its injury to this excessive bending. While the hail must have helped accentuate this injury, it was difficult to find any injury which could be clearly attributed to hail alone. In most cases there was no evidence whatever of any laceration or even breaking of the epidermis until a long while after the storm, when the dead tissue had dried and shrunk away from the healthy part of the leaf. Definite creases with broken epidermis in the weaker tissues between the veins were caused by wind in many cases but this never resulted in the death of any considerable area of leaf tissue.

In addition to the typical storm injury, there occurred in Norway maples, and to a less extent in sugar maples, a peculiar injury which we have termed "maculate," involving very small polygonal dead spots scattered throughout the leaf without reference to margin or veins. Here also there was little or no breaking of the epidermis. While worst on the side of the tree most exposed to the storm, this maculate injury occurred more or less on all parts of the tree. It is thought that this injury may have been due to hail bruising, but there is nothing to prove this. Trees which had been previously injured by drouth seemed as free from this maculate injury as those which had not suffered from drouth. In no case was this injury of serious consequence as it did not cause the death of any leaves, and from a little distance simply dulled somewhat the normal color of the foliage. The killed areas were later somewhat increased in size, probably as a result of the work of weak parasitic fungi, which were able to spread by the start afforded them by the already killed tissue. Similar extension of non-parasitic spots in apple leaves has been previously observed by the senior writer in the case of inoculations with *Coniothyrium pirina*,[4] and by Roberts,[5] in work with Alternaria. Later in the season the leaf broke somewhat around the edges of the spots, the breaking being due to drying of the dead tissue and not to direct action of the storm. This type of injury was provisionally attributed to hail.

So far as could be observed the drouth preceding the storm was not a predisposing factor to storm injury, as trees which had previously shown drouth injury were not more damaged by the storm than trees which had not shown drouth injury, and street trees were less affected than those in open parks. It is presumed that most of the damage was caused by the breaking of cell walls in the leaf interior with consequent loss of water

[4] Hartley, Carl. Some apple leaf spot fungi. Science N. S. **38**: 157–9. 1909.

[5] Roberts, J. W. Experiments with apple leaf spot fungi. Journ. Agri. Research **2**: 57–65. 1914.

holding capacity. The main facts to be deduced from these observations are that sugar maple leaves proved very susceptible to injury by the high velocity storm, while Norway maple was especially susceptible to drouth injury. It does not necessarily follow that sugar maple would be so much more susceptible than other species to injury from all storms, irrespective of time of year or other variable factors; neither does it follow that Norway maples would be much more susceptible than the other species observed to a drouth occurring at some other time of year, or of a less severe but more protracted character. In nearly all the species affected by either drouth or storm the trees most severely injured put out a few leaves in September. On the horse chestnuts defoliated probably by drouth, and in other cases of early drouth defoliation, the leaves put out at the end of the season were very small. In the cases of storm defoliation, especially with basswood, the new leaves put out were noticeably large, and remained healthy long after frost had killed the older remaining leaves. In practically all cases, including the entirely defoliated pin oak near the Treasury, twigs and buds seemed fairly healthy after defoliation, and serious permanent damage to the trees is not expected.

In localities studied outside of the District, none showed material storm injury since there had been neither unusually high winds nor notable hail. Observations in Pennsylvania and New Jersey were useful chiefly in distinguishing between drouth effects and the supposedly parasitic blotch type.

In closing, it is especially interesting to note the resemblance of leaves injured by storm to those affected by drouth, particularly on sugar maple. Here the leaf is often unlacerated and gives little or no external evidence of mechanical injury. Damage as in drouth injury is chiefly marginal and between the veins. The only material difference seems to be that drouth injury is more closely confined to the leaf margins, while storm injury tends more conspicuously to affect areas situated between the veins as well. Inspection of the tree or knowledge of previous weather conditions, or both, seem necessary for positive differentiation between the two types.

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SOME OBSERVATIONS ON ORDINARY BEET SCAB

B. F. Lutman and H. F. Johnson

With Four Figures in the Text

The identity of beet and potato scab, as far as the causal organism is concerned, was well established by Bolley[1] and Arthur and Golden.[2] Bolley found in North Dakota "a disease of beets identical with the deep scab of potatoes" and that out of fifteen fields producing scabby beets fourteen had been planted with potatoes the previous year. Arthur and Golden isolated, in Indiana, an organism from scabby beets identical with that obtained by Thaxter[3] from scabby potatoes. They were further able to convey the potato scab to the beet by placing a piece of scabby potato against the side of a growing beet root.

A careful cultural study of eight organisms obtained from scabby beets from various parts of Vermont has convinced us of their identity with those already isolated in great numbers at this station from scabby potatoes and also, that all eight were the same organism (*Actinomyces chromogenus*). Minor differences in chemical and cultural behavior were observed but these were not greater than those obtained from separate isolations from the potato.

Some differences were observed, however, in the number of successful inoculations obtained on beets in the greenhouse in the five strains used. Only one of these would produce any number of scabs on injured beets, 18 per cent were successful with this organism, while with the other four, only occasional scabs would result, and these may have been due to other infections. Superficial injury to the beets led to about 50 per cent of successful inoculations with all five strains of the organisms. Deep injuries, such as those that might be made with a hoe, showed scabs in only a few cases after inoculation. It would seem, therefore, that there are differences in virulence in the various strains of organisms, and that a removal of the corky protective layer from the root is the best way to help the bacterium produce a scab.

The organism producing the ordinary scab on the beet and potato is undoubtedly identical, but the lesions it produces on the two hosts

[1] Bolley, H. L. Prevention of potato scab. N. D. Sta. Bul. 9. 1893.

[2] Arthur, J. C. and Golden, K. Diseases of the sugar-beet root. Ind. Sta. Bul. 39. 1892.

[3] Thaxter, R. The potato scab. Conn. Sta. Rpt. 1890.

are quite dissimilar. The scabs on the potato arise frequently at the lenticels but may originate on other portions of the tuber,[4] and the cork and cork cambium are the only tissues involved. The presence and growth of the organism on the outer layers of the cork brings about a stimulation of the cork cambium to produce cells, abnormal both as to size and number. The scab tissue is composed entirely of cork cells, although some investigators have claimed that some parenchyma occurs in some forms of potato scab (the bulging scab of Frank and Krüger).

Arthur and Golden noticed that the beet scabs were larger and more bulging than those of the potato, and that the brown outer portion of the scab could be wiped off, exposing the uncolored cork tissue beneath. Bolley simply states that the beet scab is formed at the ends of the pith rays in the region of the young roots. The inference is that the scabs are modified roots. He further observed that, while the deep scab of the potato is sunken, the similar disease on the beet bulges above the surrounding surface.

The growth of the beet root as followed by Droysen, quoted by de Bary,[5] results from an external cambium. A new cambium is formed eight to ten times before the beet arrives at maturity, the regeneration proceeding each time from the outer cells of a layer of parenchymous tissue. Growth and cell division continue in this new layer for a time, but strands of wood and bast become differentiated in it and a new cambium is developed near the exterior of the root. This means that the cambium layer is placed as a result of this method of growth always at or near the surface.

The bacterium producing the disease seems to grow entirely superficially on the potato and beet, and it is probably only by the absorption of the toxic products that its stimulation is produced. Arthur and Golden noticed that the beet was often stained to a considerable depth due to the penetrations of the dark brown excretions of the organism. The beets used were presumably of a light colored variety, which showed this staining much more readily than the red fleshed garden varieties employed in the present work as the stain on the latter could not be observed beyond the first outer ring. It is by the absorption of these products, however, that the cambium is stimulated to form an abnormally large number of parenchyma cells, with a swollen mass of this sort of tissue as a result (fig. 1). The differentiation of these cells into wood and bast is also sometimes hindered by the toxic action of these substances and

[4] Lutman, B. F. The pathological anatomy of potato scab. Phytopathology **3**. 1913.

[5] De Bary, A. Comparative anatomy of the phanerogams and ferns. Eng. trans. Oxford. 1884.

the ring of vessels is broken at the point immediately under the scab. The depth of this break depends upon the amount of growth after the infection has occurred, in most cases only a ring or two, but in large beets, nearly full grown, transplanted in the greenhouse and inoculated,

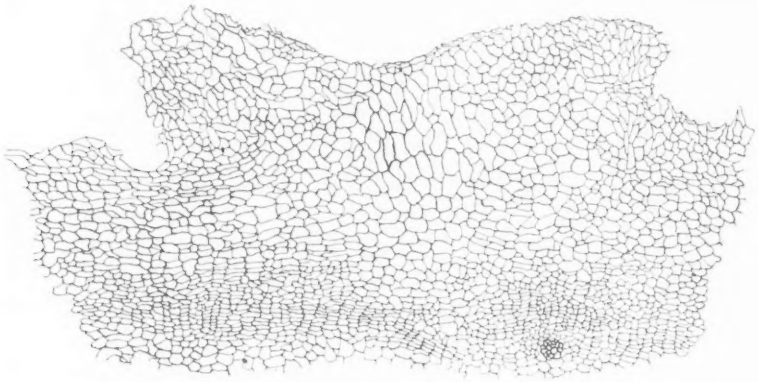

FIG. 1. Cross-section of a very young beet scab involving only the outer layer of the beet. Magnification about fifty diameters.

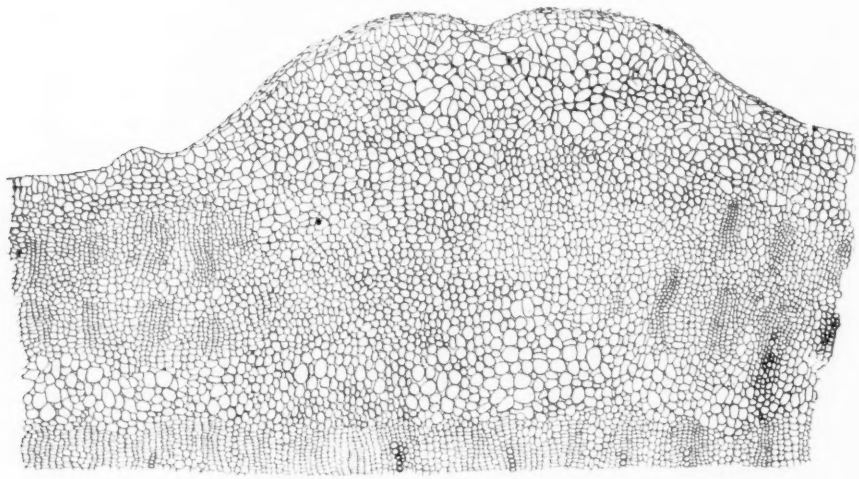

FIG. 2. Semi-diagrammatic cross-section of an old scab from a beet grown in the greenhouse showing three layers of the beet affected. These layers were very thin.

the interruption of three or four rings has been observed (fig. 2). The cells composing this spongy mass of parenchymous tissue are a little larger than those in the other parts of the root and toward the exterior are often lengthened in radially (fig. 3).

In the great majority of cases of beets grown in the garden, the protruding portion is due to an excess in growth of the rings directly under the infected spot and few if any of them are interrupted (fig. 3). The

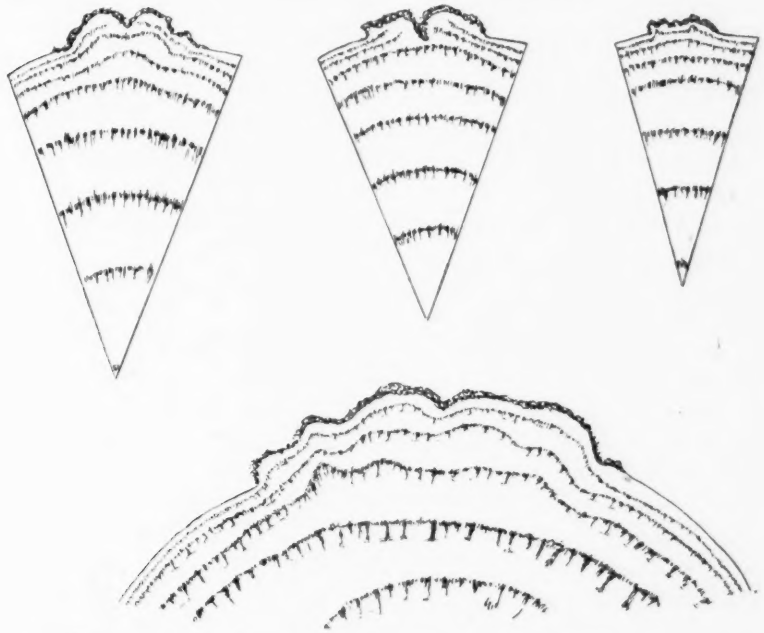

FIG. 3. Cross-section of beets grown in the garden. The rings of vessels have bowed out to form part of the scab tissue.

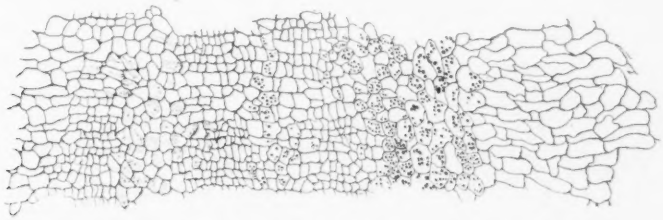

FIG. 4. Cross-section of a scab showing the numerous fat droplets present in the cells and the radial lengthening of the cork cells near the surface. Magnification about eighty diameters.

bulk of the tissue, however, is a soft parenchyma covered with a thickened layer of cork that may be readily wiped off, exposing the former cells.

The presence of spherical bodies in the cells under the scab tissue on the potato has been noted by a number of observers and was shown by one of the authors to be abnormal products of a fatty nature or at

least impregnated with fat. The cork cambium is free from them, but the cells of the outer layers of the starch parenchyma of the tuber contain great numbers. Their diversity in size and their staining reaction with osmic acid preclude the idea of bacteria and indicate that they are degeneration products in unhealthy cells.

Fixed and stained sections of beet scabs show similar bodies in the parenchyma cells lying between the rings. The larger spheres are found in the outer rings of parenchyma while those in the inner layers are often so small as to be barely distinguishable from the remaining portions of the cytoplasm (fig. 4).

The changes in the anatomical structure of the sugar beet, induced by similar organisms and described by Krüger[6] as "girdle scab," result in a root, contracted by a ring of cork tissue around its upper portion. Krüger claims that the organisms isolated from these scabs are distinct from that producing the potato scab (and of course the beet scab with which it is identical) and has made distinct species of them although the cultural characters of some of them are not markedly different from those of the Thaxter organism. It is certain, however, that the morphological effects they bring about are decidedly more drastic.

The explanation of scabbing of the potato and beet, while many other root and tuber plants escape, undoubtedly lies in the fact that some sort of a cambium—either already present or easily regenerated—is so close to the surface that the toxic substances produced by these thread bacteria readily affect it. The same organism occurs in the greatest abundance in the soil and, as Beijerinck[7] has shown, on the roots of many plants, but the anatomical structure of the underground portions of the majority of them is not of a nature to expose the cambium layers, through lenticels or otherwise, and they, therefore, escape scab formation even though covered externally by growths of the same organism. Its parasitism is dependent on a particular type of root or tuber structure and when this is not present it is forced to live as a saprophyte.

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF VERMONT, BURLINGTON, VT.

[6] Krüger, F.: Untersuchungen uber den Gürtelschorf der Zuckerrüben. Arbt. Biol. Anst. **4**: 3. 1904.

[7] Beijerinck, M. W.: Über Chinonbildung durch Streptothrix chromogena. Centralbl. f. Bakt. Abt. 2, **4**: 2–12. 1910.

LONGEVITY OF PYCNOSPORES AND ASCOSPORES OF ENDOTHIA PARASITICA UNDER ARTIFICIAL CONDITIONS[1]

F. D. Heald and R. A. Studhalter

With Plate II

INTRODUCTION

Both pycnospores and ascospores of the chestnut blight fungus are subjected in nature to a variety of conditions. The pycnospores after reaching maturity may be extruded in sufficient quantity to form spore-horns, or large numbers may be retained in the pycnidia during periods unfavorable for growth. During rain periods, spore-horns that are developed are soaked with water and the constituent spores dissipated, or the developing spores are washed down before accumulating in sufficient numbers to form visible spore-horns. These separated pycnospores lodge on the bark of the host or other nearby substrata, some are carried into the soil, and others are carried away by birds or insects, but sooner or later they will be subjected to drying. Ascospores are forcibly ejected and if they come in contact with moisture, germinate at once. Many expelled spores undoubtedly dry out before any opportunity is offered for germination. The effect of desiccation of pycnospores and ascospores of the chestnut blight fungus under different conditions is therefore one of the important phases of physiology bearing on the general problem of dissemination.

Pycnospores in the pycnidia, in spore-horns attached to the bark, or in separated spore-horns, are very resistant to desiccation as has been shown by Anderson (1). Later Anderson and Rankin (2) report that pycnospores in the spore-horn stage "showed very little diminution in the percentage of viable spores at the end of one year." The same writer states that "On the other hand, when the spore-horns were dissolved in water and the water allowed to evaporate leaving the spores in a separated condition on the slide, they did not retain their viability longer than a month." They give no results showing the actual percentage of spores viable after different periods of drying under these conditions. The work of Heald and

[1] The writers wish to acknowledge valuable assistance from Mr. M. W. Gardner, who was associated with them during the earlier part of the work presented in these pages.

Gardner (3) has shown however that a certain percentage of the spores dried on soil retain their vitality for a much longer period than one month.

Ascospores retained in the perithecia in the bark are also very resistant to desiccation. Anderson and Rankin (2) report a large percentage capable of germination after eighteen months of drying. On the other hand, ascospores expelled from the perithecia and caught on glass slides are more sensitive to desiccation. According to Anderson (1) ascospores dried under these conditions failed to germinate after five months and six days. No work comparable to that in which separated pycnospores were dried on glass, has been reported for ascospores.

TABLE 1

Longevity of pycnospores of Endothia parasitica in water

NO. OF DAYS IN WATER	NO. OF VIABLE PYCNOSPORES PER CENTIMETER AT VARIOUS TEMPERATURES		
	42° F.	55° F.	75° F.
0	945,300	1,421,400	1,221,300
7	1,036,800	1,214,700	749,700
21	717,600	724,500	Contaminated*
28	882,000	874,800	
35	573,300	305,500	
42	487,500	485,100	
49	340,200		

* A series at a later date showed that there was no material differences at 75°F.

THE LONGEVITY OF PYCNOSPORES IN WATER

Since pycnospores do not germinate in water, the question of their longevity when immersed in water is of importance as shedding some light on the general problem of dissemination. If they survive long periods of immersion in water, dissemination by water currents following periods of heavy rainfall is a possibility that merits consideration.

In order to determine the longevity of pycnospores when immersed in water a single small spore-horn was placed in each of three flasks containing 100 cc. of sterile tap water, and the flasks were shaken to secure uniform suspensions. The number of pycnospores per cubic centimeter was determined at once by the poured plate method, and the flasks were stored at different temperatures. Determinations of the number of spores remaining viable were made at weekly intervals. The results are presented in table 1.

The successive tests showed a gradual reduction in the number of spores remaining viable, but at the end of forty-nine days approximately one-third were still capable of germinating.

A similar test was made later in which the spore suspension was kept in a cold room giving a freezing temperature. The reduction in the number of viable spores was less pronounced (table 2) than at the higher temperatures of the previous tests. From these tests it is apparent that pycnospores suffer but little in suspension in water.

TABLE 2

Longevity of pycnospores of Endothia parasitica in water at low temperatures

NO. OF DAYS IN WATER	RANGE OF TEMPERATURE SINCE LAST TEST DEGREES FAHRENHEIT	NO. OF SPORES PER CUBIC CENTIMETER
0	−32.0	55,993
1	−32.0	54,229
2	−32.0	55,245
4	26.5–31.0	57,190
6	22.5–30.5	56,875
10	23.0–31.0	56,515
13	25.0–33.0	54,927
16	27.0–34.0	58,102
27	23.5–33.5	57,303
36	26.5–41.0	50,947
41	29.5–42.0	50,566

THE EFFECT OF DESICCATION ON SEPARATED PYCNOSPORES

Our first work on the effect of drying on separated pycnospores was made by the hanging-drop method. This method did not give very satisfactory results but some of the work will be presented since it points to the character of the surface on which desiccation takes place as influencing the results. A stock suspension of pycnospores was made in tap-water on a glass slide, and small quantities transferred to tap-water, distilled water, rain water, and physiological salt solution, and dried on cover glasses and on cork plates. The original stock solution on glass was also allowed to dry and was tested the same as the others. The results are presented in table 3.

Although the tests show some irregularities to be charged to the method, they indicate that the conditions of desiccation on glass are more severe than on cork, a surface which is more comparable to the bark of the tree. The results also indicate that the concentration of the suspension diminishes the injurious results of desiccation, since there was a much higher percentage of germination from the original stock suspension than from any of the dilutions.

The following tests were made by the use of plate cultures and they yielded more reliable results. In this work a suspension of pycnospores was made by adding one or two small spore-horns to 100 cc. of sterile water. After obtaining a uniform suspension, 1 cc. was added to a second flask containing 100 cc. of sterile water. From this very dilute stock suspension of spores, one drop was added by a sterile 1 cc. pipette to each of a collection of sterile cover glasses. Plate cultures in 3 per cent dextrose agar were made from five drops immediately, five more were used as soon as dry, and a like number at intervals thereafter until no viable spores remained. The cover glasses carrying the dried suspensions were stored in sterile Petri dishes. Some preliminary tests showed that pycnospores dried on cover glasses did not readily wash off when the cover glass was flooded with the melted agar. To avoid error from this source, the cover glass to

TABLE 3

Effect of desiccation on viability of pycnospores determined by hanging-drop cultures

LIQUID USED FOR SUSPENSION	SURFACE ON WHICH SPORES WERE DRIED	GERMINATION PERCENTAGE			
		4 hours after dry	3 days after dry	7 days after dry	14 days after dry
Tap water	Glass	trace	0	trace	trace
Distilled water	Glass	0.50	trace	trace	0
Rain water	Glass	trace	trace	trace	1
Phys. salt solution	Glass	0	trace	trace	trace
Tap water	Cork	5.00	20–25	9.0	12.00
Distilled water	Cork	0.75	1.0	4.0	5.75
Rain water	Cork	2.00	2.5	6.0	6.00
Phys. salt solution	Cork	0.50	trace	6.5	2.50
Original stock in tap water	Glass	25.00	27.0	35.0	?

be tested was placed in the sterile Petri dish, the spore film covered with a few drops of sterile water and the film thoroughly rubbed up so as to separate the spores, before introducing the melted medium. The results of a test made by this method are given in table 4.

It may be noted from this test that immediately after drying only 30.2 per cent of the pycnospores remained viable. Two earlier tests made by the same method were questioned since it was determined that the pycnospores have a relatively low thermal death point (50°–52°C.), and so might easily be killed by failure to sufficiently cool the medium used. One of these tests gave only 2.89 per cent of viable spores after 24 hours of drying, while the other showed no viable spores at the end of a similar period.

It has been suggested by Anderson and Rankin (2) that the gelatinous material covering the pycnospores serves as a protection in the drying process. This is in a measure substantiated by our results obtained by

TABLE 4

Effect of desiccation of pycnospores on glass as determined by plate cultures

LENGTH OF DRYING	NO. OF COLONIES IN EACH PLATE					AVERAGE NO. OF COLONIES	PERCENT OF VIABLE SPORES
	1	2	3	4	5		
Control (not dried)	228	222	250	219	321	248.0	
Just dry	93		81	73	52	75.0	30.20
24 hours	30	26	52	16	32	31.0	12.50
46 hours	36	35	46	33	16	33.0	13.30
3 days		26	31	26	30	28.0	11.20
4 days	13	17	42	34	21	25.0	10.00
5 days		9	17	9	34	17.0	6.80
10 days	0	0	0	1	0	0.2	0.04
20 days	0	0	0	0	0	0	0

the hanging-drop method (table 3). With this idea in mind a series of tests was made in which the pycnospores remained in suspension for varying lengths of time. The suspensions kept for 6.5 and 25 hours before making the cover-glass films were shaken frequently so as to insure as complete a solution of the mucilaginous coatings as possible. The same method was employed as outlined for table 4, and only a summary of the results will be offered (table 5). Although the spores in suspension for only 40 minutes showed the highest number viable immediately after drying, they showed no superior resistance to desiccation in the later tests. It is possible that there was sufficient washing in each series to dissolve the mucilage, but if this covering does protect the spores, the behavior is contrary to the results reported by Edgerton for the spores of the cotton anthracnose fungus. According to this writer (4) spores allowed to dry down in their mucilaginous matrix lost their ability to germi-

TABLE 5

Effect of washing on longevity of desiccated pycnospores

LENGTH OF DRYING	SERIES I. IN SUSPENSION 40 MIN.		SERIES II. IN SUSPENSION 6.5 HRS.		SERIES III. IN SUSPENSION 25 HRS.	
	Av. no. of colonies per plate	Percent of viable spores	Av. no. of colonies per plate	Percent of viable spores	Av. no. of colonies per plate	Percent of viable spores
Control (not dried)	5996.0		4640.0		7973.0	
Just dry	2066.0	34.4000	1054.0	22.700	1833.0	23.6000
24 hours	35.0	0.5800	189.0	4.000	459.0	5.7000
3 days	50.0	0.8300	87.0	1.800	184.0	2.3000
7 days	5.2	0.0860	41.2	0.887	41.0	0.5140
14 days	0.2	0.0033	2.0	0.043	0.2	0.0025

nate in 20 days, while those from which the mucilaginous substance was removed by washing, germinated at the end of 30 days.

Field tests were planned in which suspensions of pycnospores were to be dried on living bark, leaves, etc., but only preliminary results have been obtained. It is worthy of note, however, that a pycnospore suspension dried on living bark in the open showed 42.58 per cent viable immediately after drying and 9.44 per cent viable at the end of 24 hours. Similar results were obtained from tests of pycnospores dried on living leaves. All of our work points to the fact that conditions of desiccation on a glass surface are more severe than on surfaces on which spores would be dried under natural conditions in the field. Tests made from spores dried on glass surfaces are then not a reliable index of the maximum longevity under field conditions.

THE EFFECT OF DESICCATION ON ASCOSPORES

It seems probable that the longevity of ascospores naturally expelled from the perithecia and collected on glass slides is not a reliable index of their persistence in nature. In this condition they are embedded in more or less gelatinous material expelled from the asci and are collected in more or less dense aggregates. Under natural conditions in the field, the expelled ascospores are separated and carried away by air or wind currents, and would dry as isolated spores, either before or after being washed by rains.

The effect of desiccation on separated ascospores was tested first by the hanging-drop method, dextrose agar being the medium used. A suspension of freshly expelled ascospores was made in tap-water and small portions were allowed to dry on glass and cork plates. The percentage of germination was obtained as soon as dry and at intervals thereafter. Under such conditions there was a drop from 70 per cent to 19 per cent germination as a result of drying for 24 hours; a second test of spores dried from distilled water gave a decrease from 53.4 per cent to 11 per cent after 24 hours. There was but slight difference between ascospores dried on glass and on the cork plates, but spores on the cork plates were more resistant to desiccation.

The plate culture method was also used for testing the longevity of desiccated ascospores. The technique was essentially the same as that described for the pycnospores, but the suspension was examined microscopically to determine the number of ascospores in a drop, and the number adjusted by additions or dilutions as was necessary. Freshly expelled ascospores collected on flamed slides were always used, and it was the aim to have each drop contain 500 to 1000. The results of a test by this method are recorded in table 6.

The results in this case show in a more striking manner than in the hanging-drop method, that separated ascospores are poorly equipped to withstand desiccation. With some irregularities there is a gradual decrease from 5.37 per cent of viable spores just after drying to 0.17 per cent at the end of 28 days. This rapid decrease in number of viable spores is well represented in plate II which shows a series of representative cultures taken from those on which the above table is based.

The length of time that ascospores are retained in water before drying may influence their resistance to desiccation. The longer period in water may more completely remove the mucilaginous coating, while germination processes will be initiated in a few hours. A comparison was made of two sets of desiccated ascospores, one being dried as soon as possible, the other after washing in water for 6 hours. The same method

TABLE 6

Effect of desiccation of separated ascospores on glass as determined by plate cultures

LENGTH OF DRYING	NO. OF COLONIES IN EACH PLATE					AVERAGE NO. OF COLONIES	PERCENT OF VIABLE SPORES
	1	2	3	4	5		
Control (not dried)	563	525	622	644	568	584.4	
Just dry	54	29	26	29	19	31.4	5.37
24 hours	7	15	10	17	41	18.0	3.08
2 days	18	17	13	41	19	21.6	3.69
3 days	10	9	2	0	4	5.0	0.86
4 days	4	30	6	11	16	13.4	2.29
5 days	0	4	3	6	2	3.0	0.51
10 days	2	6	4	30	3	9.0	1.54
18 days	3	3	0	0	4	2.0	0.34
28 days	3	0	0	0	0	1.0	0.17

was followed as recorded in table 6, and only a summary of the results will be presented (table 7).

Although some of the ascospores held in water for 6 hours remained viable as long as those washed for only 40 minutes, the reduction in the germination per cent of the washed ascospores was the more pronounced.

Some tests were made at Martic Forge, Pennsylvania, to determine whether ascospores dried on living bark and leaves in the fields were less susceptible to injury from desiccation than those dried on glass in the laboratory. Essentially the same method was used, the drops of water containing the ascospores being placed on marked areas and the sprouts used covered by a large tent fly during the night to protect them from possible rains. The test here reported (table 8) was a preliminary one and

TABLE 7

Effect of retention in water on longevity of desiccated ascospores

LENGTH OF DRYING	SERIES I. IN SUSPENSION 40 MINUTES		SERIES II. IN SUSPENSION 6 HOURS	
	Av. no. of colonies per plate	Percent of viable spores	Av. no. of colonies per plate	Percent of viable spores
Control (not dried)	1130.0		1304.0	
Just dry	85.2	7.54	76.0	5.83
1 day	156.6	13.86	78.2	6.00
4 days	33.6	2.97	8.6	0.66
9 days	50.8	4.50	0	0
14 days	4.0	0.35	0	0
20 days	8.8	0.78	0.2	0.02
29 days	1.2	0.11	1.4	0.11
35 days	0	0	0	0

is not offered as conclusive, since more work is needed to substantiate the results.

The prolonged vitality of ascospores dried on living leaves and bark is in agreement with the results obtained in preliminary tests with pycnospores. It seems probable that the greater vitality is due to a lesser degree of desiccation as some moisture would probably be supplied from the living cells with which the spores were in contact.

TABLE 8

Effect of desiccation of ascospores on living bark and leaves

LENGTH OF DRYING	DRIED ON LIVING BARK		DRIED ON LIVING LEAVES	
	Av. no. of colonies per plate	Percent of viable spores	Av. no. of colonies per plate	Percent of viable spores
Control (not dried)	2700.0		3345.00	
Just dry	1187.2	43.97	707.25	21.14
1 day	629.4	23.31	352.00	10.52
4 days	503.4	18.64	488.00	14.59

SUMMARY

1. Pycnospores retained in suspension in water at various temperatures show a very slow but gradual reduction in the number remaining viable. At temperatures from 42° to 75°F., one third were viable at the end of 49 days. At freezing temperature or below the loss of vitality was even less pronounced.

2. Pycnospores when separated by water and allowed to dry are much ess resistant than if dried in the form of spore-horns. A very large num-

ber of separated pycnospores, dried on glass, are killed in the process of drying, the per cent varying from 66 to 78, as determined by plate cultures. None remained viable for longer than two weeks.

3. Ascospores when separated and allowed to dry from suspension in water are much less resistant to desiccation than when dried in the form of spore prints on object slides. A very large number of separated ascospores dried on glass are killed in the process of drying, the per cent varying from 86 to 94, as determined by plate cultures. None remained viable for longer than 35 days.

4. Desiccation of spores on a glass surface gives more severe conditions than those usually found in nature. Both pycnospores and ascospores when separated and dried on living bark and leaves show a greater vitality than if dried on a glass surface.

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EXPLANATION OF PLATE II

Series of representative cultures from test recorded by table 6. Each plate represents the colonies developing from the ascospores in one drop of suspension after drying on cover glasses.

FIG. A. Control, not dried, 644 colonies.

FIG. B. Just dry, 54 colonies.

FIG. C. After 24 hours, 15 colonies.

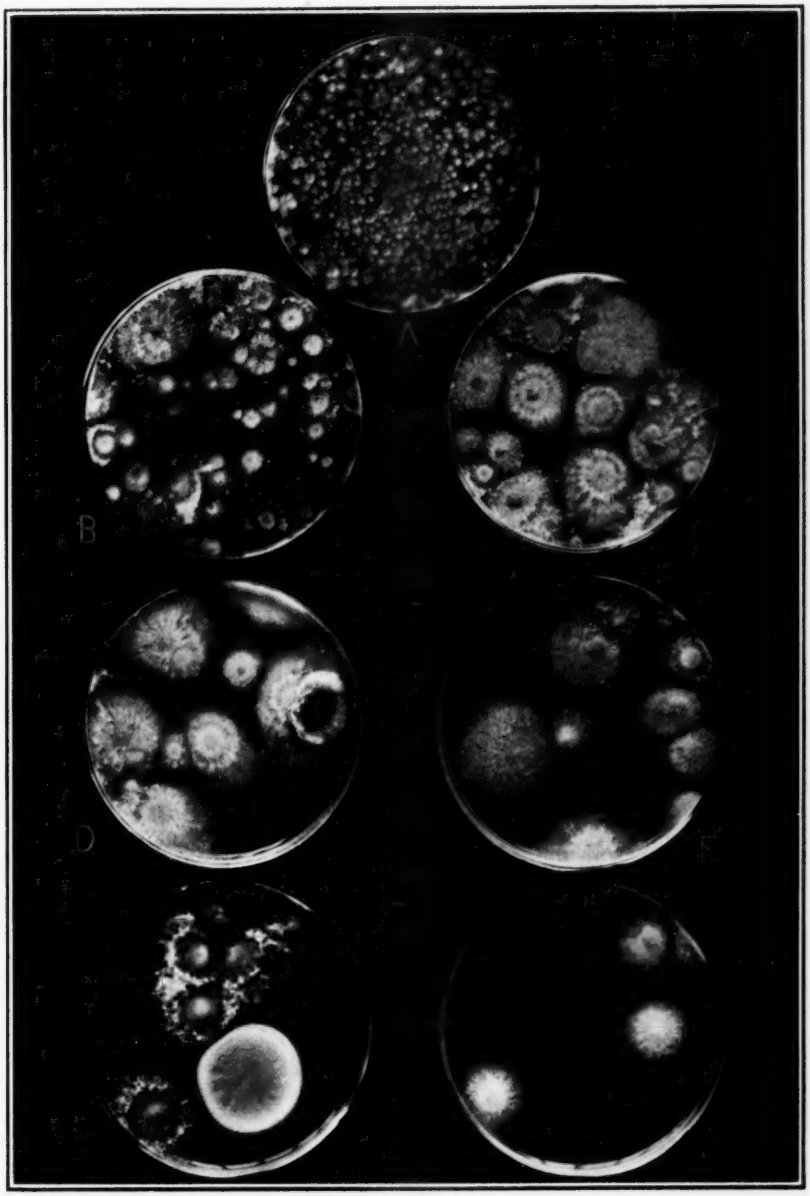
FIG. D. After 2 days, 13 colonies.

FIG. E. After 3 days, 9 colonies.

FIG. F. After 4 days, 6 colonies (1 foreign colony).

FIG. G. After 5 days, 4 colonies.

The experiment was started on May 14, the photograph taken on May 26.



HEALD AND STUDHALTER: ENDOTHIA PARASITICA

NOTES ON THE CHESTNUT BARK DISEASE

J. T. Rogers and G. Flippo Gravatt

INOCULATIONS ON THE CHINQUAPIN

In Virginia the chinquapin in the vicinity of infections of the chestnut bark disease is very rarely diseased. However, the disease has been found on this species in several of the northern states and in one case in Virginia. As the chinquapin is very prevalent in Virginia, especially in the counties east of the chestnut zone, a definite test was made to determine its supposed resistance to the bark disease.

During July and August, 1913, 197 inoculations were made on 61 chinquapins in a patch near Leesburg, Virginia. Most of the chinquapins inoculated were rather small, though one tree measured 10 inches in circumference. The agar cultures used were made from material collected on the chestnut at Fontella, Virginia, and from material collected by Meyer on the Chinese chestnut in China. The inoculating material was inserted through small slits or holes made with a scalpel and these were not covered.

Of the 197 inoculations, 88 per cent gave positive results and the 30 checks remained uninfected. In a few cases the inoculations of July 21 had girdled the stems by October 6, 1913. The cankers resulting from inoculations made on August 16 and July 21 had developed a number of pycnidia with spore horns by October 6. It was thought that perithecia would be formed during the fall or winter, but an examination in March and again in August, 1914, failed to show any.

Three inoculations on chinquapin roots under soil gave positive results, but the growth of the fungus was very slight and the fans were not exactly typical. In March, 1914, on one of the small cankers there were several pycnidia.

From the growth records obtained at the March note-taking, there were indications that the culture of Chinese origin was slightly more virulent than the culture from Fontella, Virginia. Because of the smaller size of the chinquapins inoculated, at this time practically all of the cankers from the latter culture had completely girdled the stems. It was therefore not possible to secure definite data as to any difference in the virulence of the cultures. The average growth for the year, of the 5 cankers of Chinese origin inoculated August 16, 1913, which had not completed their girdle on August 15, 1914, was 6.8 inches.

These inoculations indicate that the chinquapin in Virginia has no more resistance to the girdling growth of the blight fungus than has the chestnut. However, the chinquapin does not have as many insect and other injuries as the chestnut, and this is the probable reason for its freedom from the disease in the field.

ONE YEAR'S SPREAD OF THE CHESTNUT BARK DISEASE OVER A SMALL AREA

Although several hundred articles on the chestnut bark disease have been published, no specific reference to the increase from year to year in a cankered or spore-producing area in a woodlot or of an individual infection has been made. To secure information on this particular point, a plot, 35 by 45 yards in dimension, was selected within the advancing edge of a large infection near Bluemont, Virginia. Most of the diseased trees, as would naturally be expected, were in the half of the plot nearest the center of the infection. There were in this plot 140 chestnut trees, which made up approximately 90 per cent of the stand. Most of these trees were of coppice growth and ranged from 1 to 19 inches in diameter, averaging about 4 inches.

On May 1, 1913, every chestnut tree in this plot was carefully examined and the cankers were measured and their edges marked with a lumber crayon. At this time 40 of the 140 trees were diseased, having a total of 58 cankers. Several of these cankers had already girdled the trees and therefore could grow only in a vertical direction. The total area of these 58 cankers was 20.79 square feet.

On September 1, 1913, counts and measurements were again made. Fifty-seven new cankers had developed since the first measurements. The total area of the cankers was 45.04 square feet, an increase of 116.6 per cent during the four months.

On May 1, 1914, final measurements were taken. The number of cankers had increased from 58 to 199, making 141 new ones, or a 243.1 per cent increase for the year. The total area of the cankers amounted to 95.80 square feet, an increase of 75.01 square feet, or 360.8 per cent during the year. The number of diseased trees increased during the year from 40 to 83. The growth of the blight in this particular plot was a fair average for the advancing edge of this particular infection. However, the percentage of chestnut, the density of the stand, the size and condition of the trees, and the temperature and moisture conditions, all are important factors which must be considered in determining the rate of spread. Variations in these factors make accurate comparisons between infections in different sections of the country difficult.

At the average rate of diameter growth of the disease cankers at Bluemont, Virginia (6.35 inches for the year), it would require a number of years for a single canker to girdle a large tree. A number of cankers in this plot, which on examination at the end of the year appeared to have developed from a single infection, were actually made up of 3 or 4 separate cankers which had grown together. In this manner trees are girdled in a much shorter time than the rate of growth of single cankers would indicate.

SOME OBSERVATIONS ON ABORTIVE SPOROPHORES OF WOOD-DESTROYING FUNGI

JAMES R. WEIR

No satisfactory explanation has yet been given of the identity of the very peculiar, hard, brown, sterile, abortive fungus so common in some localities on birches. That this abnormality is a sterile form of some Fomes has long been recognized. It has been referred to *F. igniarius* (L.) Gillet, the usual Fomes on birches, or its variety, *F. nigricans* Fr. *Fomes everhartii* Ellis on Quercus, *F. rimosus* Berk. on Robinia and *F. pomaceus* Pers. on Prunus are somewhat similar to *F. igniarius*, but as noted are quite different in their host relations, neither are they known to produce sterile structures. Both the typical form of *F. igniarius* and its variety are occasionally observed on the same tree, but there is no record known to the writer of either occurring on the same trunk together with the characteristic sterile fruiting structure.

In Greenough Park at Missoula, Montana, numerous alder trees (*Alnus tenufolia* Nutt.) are seriously infected by the typical *Fomes igniarius* making it necessary to remove some trees every year. The abortive fruiting bodies are likewise common; as high as three to five are occasionally formed on the stems of the same clump of trees. That there can be no doubt as to the identity of the sterile structures is shown by their relation and relative position with the typical fertile sporophores of *F. igniarius* on the same trees. The abnormalities are sometimes located just above, below, or occasionally between fertile fruiting bodies. A longitudinal section of the infected stem shows plainly that both the fertile and sterile fruiting structures originate from the same core of diseased wood, and indeed from the same mycelium. On clumps of the western birch (*Betula occidentalis* Hook.) springing from the same mother root, the characteristic abortive structure together with the typical *F. igniarius* is occasionally found. There is such a clump of infected birches in the park at Missoula, Montana. The writer has made collections of the abortive structures and the fertile sporophores of *F. igniarius* growing together on the paper birch (*Betula papyrifera* Marsh) in northern Michigan. The abortive sporophores, occurring generally on birches in the East, are exactly the same in appearance and structure as those found

on alder and birch in the West and must be considered abnormal forms of *F. igniarius*.

Practically in every case where two distinct wood-destroying fungi occupy the same substratum, the mycelium or the wood decayed by each is sharply outlined or bounded by infiltrated zones or thylose-like deposits in the cells. These zones or layers are similar to the lines of demarcation often appearing in the rot of a single species and which separates the diseased from the healthy wood. The antagonism of the mycelium of one species to that of another is a marked characteristic of many wood rotting fungi. *Trametes pini* seldom encroaches upon the wood of any conifer already occupied by *Echinodontium tinctorium* and vice versa. The rot of *Fomes pinicola* and that of *F. fomentarius* in the wood of the same birch tree is always sharply separated by a conspicuous black line although the decay produced by each species is quite characteristic. The same evident antagonism is often true in the case of purely saprophytic species when occupying the same substratum. The absence of any such lines of demarcation (other than those occasionally separating diseased and healthy wood) or evidence of antagonism between the mycelium in the rot of the typical *F. igniarius* and that of its most pronounced variety (*F. nigricans*) when occupying the heart wood of the same host, is an argument against the validity of the latter as a distinct species.

The abortive fruiting structures of *F. igniarius* practically in every case emerge from deep open wounds, usually a "cat face." The excellent photograph by von Schrenk and Spaulding (Bureau Plant Industry Bul. 149, fig. 2, pl. VI) shows this feature. The fertile sporophores, on the other hand, more often appear directly through the bark or at wounds where the vegetative mycelium is protected from external influences. At such points of emergence the context of the fruiting structure begins very early to form the hymenium which may be producing spores when the sporophore is not more than an inch in diameter. The collection of water in the deep open wounds, freezing and thawing, etc., has a tendency to maintain the mycelium at the point of exit in a constant vegetative condition; this and the probable oxidation of certain chemical substances within the wound due to exposure are probable causes for the formation of the peculiar abnormalities.

Abortive fruiting structures are occasionally formed by *Echinodontium tinctorium* on old and badly decayed western hemlock. The context of these structures is never materially different from the normal sporophore but the hymenium is entirely absent. Probably the most peculiar of all known abnormal structures produced by wood-destroying fungi outside the so-called genus Ptychogaster are those formed by *Trametes pini* on

the western white pine. They are usually found on old and badly diseased trees from which the normal sporophores have largely fallen. The mycelium at these old "punk knots" under some later stimulus produces most peculiar ram's-horn-like projections which are often six to eight inches in length. These bodies are usually mixed with pitch and show definite annual ridges of growth.

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A BACTERIAL DISEASE OF CULTIVATED MUSHROOMS

A. G. Tolaas

With Plate III

In the mushroom caves in and around St. Paul, an unsightly spot on mushrooms is very prevalent. The severity of the spotting varies considerably on the different cultivated varieties, those most badly affected being the large white varieties. Very often the spots first appear when the mushrooms are in the early button stage, while in other instances they do not appear before the fruiting body has attained a considerable size. Only small areas may be discolored, or the entire cap and even the gills may be involved. At first the spots are pale yellow in color, but they finally become a rich chocolate brown.

The discoloration does not extend far into the fruiting body, the most severe cases observed showing the brown color but 3 or 4 mm. below the surface. The area in the immediate vicinity of this dark discoloration is usually yellowish white in appearance, but in cases where the attack is not so severe, the flesh remains perfectly white. The disease reduces crop yield but little, but the value of spotted mushrooms is, nevertheless, considerably diminished.

Microscopic examination and poured plates, as well as tissue cultures, show that bacteria are constantly associated with the disease. The organism most constantly present has proved to be the only pathogenic form.

Pure cultures were made by placing a piece of diseased tissue on a beef agar slant. In from 36 to 48 hours a greyish-green growth developed. From this, plates were poured, and the inoculation cultures were obtained from individual colonies in these plates. Inoculations were made with a platinum loop, care being taken not to injure the surface of the fruiting body. Numerous checks were kept. Successful infection was repeatedly obtained, the tissue along the line of inoculation becoming distinctly brown. The check plants remained healthy in all cases.

The causal organism is a facultative anaerobe of the Pseudomonas type, rounded at both ends, appearing slightly oval in shape with one or two polar flagella. When stained directly from a tissue culture it varies from 1.0 μ to 1.5 μ in length and measures 0.5 μ in width. When grown on beef agar or in beef bouillon, it increases somewhat in size, some of the

bacteria from these media measuring as much as 2.5 μ long and 1.0 μ wide.

The organism is easily stained by the ordinary basic anilin stains, carbol fuchsin giving the clearest result. It is gram negative and has been found to be actively motile in hanging drops made from 24-hours-old broth cultures. Endospores are not produced, a fact shown by staining and by the heat test.

Cultural characteristics were studied on the common media. A shiny greyish-white growth accompanied by a greenish pigmentation of the medium is produced on beef and potato agar. On potato cylinders a white glistening growth which changes to a creamy white is obtained. Nutrient bouillon is clouded within 36 hours. A ring or pellicle, very thick in some cases, is then formed together with increased clouding. There is a slight production of indol. No gas is produced in glycerine, nitrate, dextrose, lactose, or sucrose broths. Acid is produced in dextrose broth but not in the others. There is no diastatic action.

Liquefaction of beef gelatine begins in 48 to 96 hours. It is at first saccate, but the medium is completely liquefied in upwards of three weeks. Litmus-milk is coagulated in from 48 to 72 hours, the color of the whey being blue. Digestion is evident soon after and is usually complete in 15 days. Reduction of the litmus takes place until no color remains except a greenish tinge which is also characteristic when the organism is grown in beef agar and beef gelatine. When grown in beef bouillon to which methylene blue is added, the color is changed to a yellowish green. Nitrates are reduced.

The organism therefore takes the group number 221.2333133. This corresponds to the group number of *B. fluorescens* except for the fact that in dextrose broth the reaction is acid instead of alkaline.

A somewhat similar bacterial disease of mushrooms cultivated in the vicinity of Paris has been described by Costantin.[1] He ascribed the name la Goutte. This name is explained by the appearance on both cap and stem, during the first stages of the disease, of globules of a colorless grey liquid of variable size. Some time after the mushrooms have been picked, brown to greenish-brown spots appear where the globules have dried, forming a clammy surface.

L. Matruchot,[2] in studying the disease described by Costantin, mentions a peculiar viscosity of the cap at the place of the stains. This he ascribes

[1] Costantin, M. Julian. La goutte, maladie du champignon de couche. Extrait des Comptes rendus des seances de la Société de Biologie. (Séance du 5 Mars, 1892.)

[2] Matruchot, M. L. Des maladies du champignon de couche la goutte. La Culture des Champignon Comestible No. 24. June, 1909.

to what he calls active perspiration of the mushrooms, small drops of colorless or yellowish-grey liquid exuding, in time darkening and eventually producing the characteristic brown discolorations.

I have not noticed any viscosity of the affected mushrooms or globules of colored liquid as described by Costantin and Matruchot. This fact is probably due to the comparatively dry conditions in the caves where the disease was studied. It is rather difficult to maintain a desirable humidity in these caves during the winter months since artificial heating is necessary for the production of the crop. This, together with a continuous draught, which is rather difficult to control under the existing conditions, has a tendency to lower the humidity. Hence the liquid exuding from the cap of the mushroom evaporates so rapidly as to prevent the presence of droplets as noted by Costantin and Matruchot.

Several experiments with a view toward devising means for controlling the disease were tried. Spraying the mushrooms with solutions of copper-sulphate, sodium carbonate, and benetol of various strengths did not seem to have any effect whatever in controlling the disease. Fumigating the beds with sulphur before planting the spawn was tried in one experiment and a crop of absolutely clean mushrooms was produced. The owner of the caves where the work was carried on now fumigates all of his caves, using about one and one-half pounds of sulphur per thousand cubic feet of space, and, as a result, the number of spotted mushrooms appearing is very small. This treatment costs about five cents per thousand cubic feet and has proved to be practicable.

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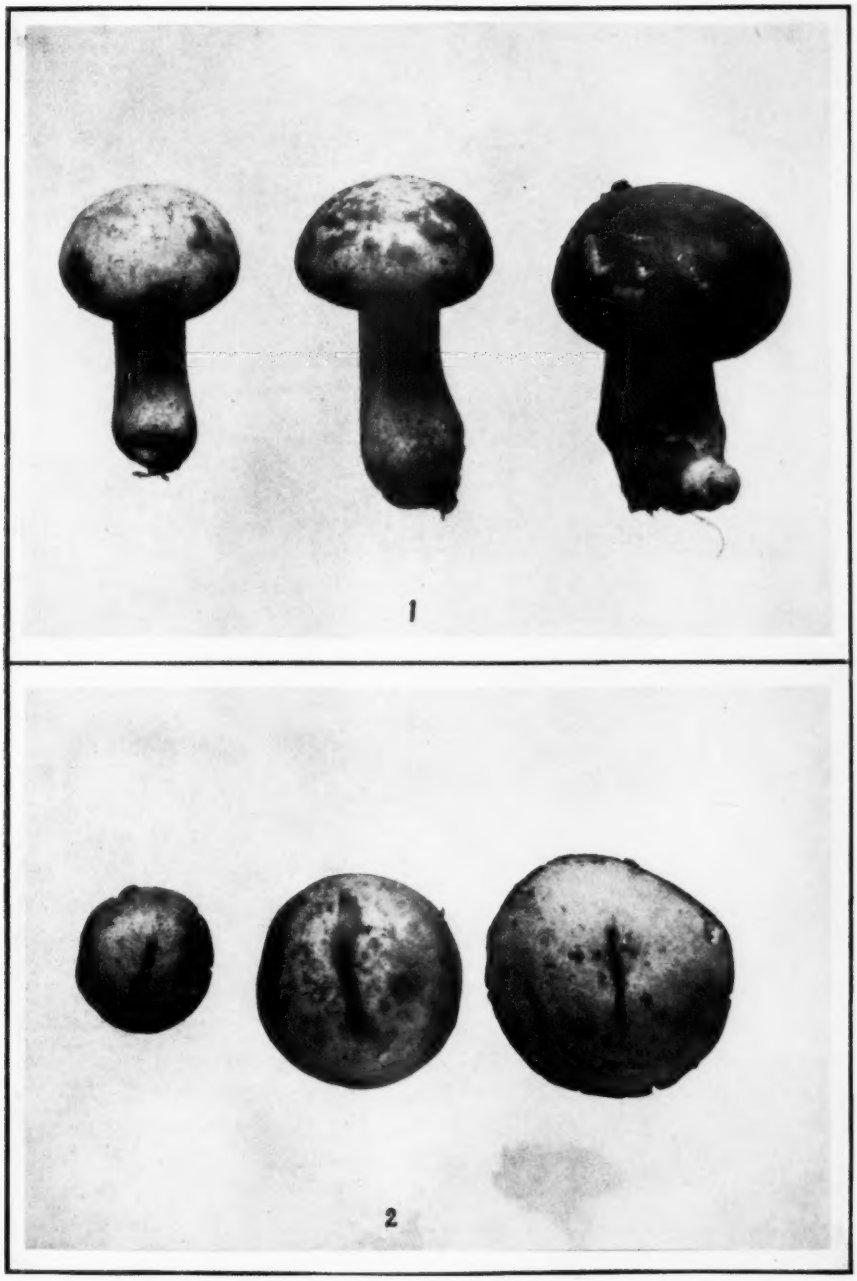
EXPLANATION OF PLATE III

FIG. 1 Three mushrooms showing different stages in the progress of the disease.
FIG. 2 Mushrooms inoculated with pure cultures showing discoloration produced.



TOLAAS: A BACTERIAL DISEASE OF CULTIVATED MUSHROOMS

NOTES UPON WASHINGTON FUNGI

JOHN G. HALL

WITH PLATES IV AND V

THE ASCOSPORIC STAGE OF CORYNEUM

In the spring of 1913, I received, for identification, an ascomycete growing upon apple twigs. The specimens were sent to me from the Okanogan country of British Columbia by William N. Brittain to whom I am indebted for the two photographs and the description of the disease upon the apple. He wrote at the time of sending the material that it followed *Coryneum foliicolum*.

The disease attacks the young twigs and often completely encircles them. This causes the leaves to dry, curl, and become brown giving them very much the appearance of the "Fire Blight" (fig. 1). The fungus occurs more abundantly upon the apple trees growing in low, poorly drained clay lands along the valley roads. It is becoming a very serious pest in that region. Specimens collected upon the first of July, 1913, showed that the disease had ceased to be active for the season, and, that in many cases, the large cankers were nearly healed over.

In the cankers formed by the Coryneum, and taking the place of the Coryneum, are found the perithecia of the ascomycete. These perithecia rupture the epidermis of the bark in a longitudinal slit or a three pointed star (fig. 2). When these places are examined with a hand lens, one is able to see that the perithecia are entirely separate from each other but may be very closely packed against each other in some of the cankers.

From the ascomycete (which I have called Otthia) I made cultures with the hope that I might be able to connect that with the Coryneum occurring earlier in the season in the same cankers. Single ascospores (fig. 4) freed from the ascus (fig. 3) were taken from drops of sterile water in which a perithecium had been crushed after being washed in formalin. These spores were taken by means of a sterile capillary pipette and deposited upon poured agar plates. These spores were watched very carefully, the plate being examined several times during every day. At the end of twenty-four hours, it was found that some of the ascospores, after becoming considerably enlarged, were beginning to germinate (fig. 5). Some of these were then transferred to drop cultures in order that they might be more readily examined. The growth of the mycelium was very

slow at first (figs. 5 and 6). After the mycelium was well started, it grew rather rapidly until the sporodochia began to appear at the end of the fourth day. The young spores are at first formed at the ends of short sporophores arising from short lateral branches of the ordinary mycelial hyphae (fig. 7). Later these form a sort of stroma, the beginning of one of which is seen in figure 9. The spores are, at first, single celled but later form two transverse walls across them, thus making them three celled (fig. 8). At this time they were brown and looked so much like the Coryneum spores that they were at once compared with the Coryneum spores (fig. 10) taken from the cankers. In every point they were so nearly alike that they were considered the same fungus.

In the spring of 1914, while out collecting, I discovered the same ascomycete (Otthia) occurring with what I took to be the same Coryneum upon Sambucus in the neighborhood of Pullman, Washington. I again made cultures from the ascomycete. The same precautions were taken with the isolations as in the previous case, and single germinated ascospores were transferred to poured plates of pea agar. The pea agar was made by boiling 40 grams of dry peas in a litre of water for half an hour. This was then filtered and 15 grams of agar added to the filtered solution.

Young spores soon appeared agreeing in every way with those grown from the apple disease. These spores were mature at the end of nine days, and they also agreed in size and septation with the mature spores in the cultures from the apple disease.

Examination of the Coryneum spores found upon the Sambucus showed them to be both two and three septate, but the two septate spores were very much more numerous than the three septate. A number of spores was counted and it was found that the proportion of two septate spores to three septate spores was 100 : 1. This proportion held good for five thousand spores counted.

Cultures were also made from the Coryneum spores found upon the Sambucus, and spores occurring in these cultures were compared with those grown from the Otthia. They were found to be in every way identical. They were also identical with those of the Coryneum from the Sambucus and the Apple

From these studies it seems to me that there can be no doubt that the fungi occurring upon the two hosts, Apple and Sambucus, are identical.

In making studies of the Coryneum stage of the fungus, I became somewhat doubtful about its being *C. foliicolum* and, after comparing it with specimens in the herbarium, I believed it to be, from all appearances, *Coryneum negundinis* Ell. and Ev. In order to be certain of this, I sent specimens of the fungus occurring upon Sambucus to Dr. Roland Thaxter of Harvard University for confirmation. He wrote back that the fungus

was not Coryneum at all but *Hendersonia diplodioides* Ell. and Ev., but that, in the older stages of the fungus, it might be very well taken for a Coryneum. On this account I suppose that we will have to call the Otthia the ascosporic stage of *Hendersonia diplodioides* Ell. and Ev.

After a study of the descriptions of all the Otthias with two celled spores, this Otthia seems to agree fairly well in all respects with *Otthia amica* Sacc. With the possible exception that the spores are a little longer than those of the last named species, they are identical and, as the measurements overlap, I believe that I am safe in calling the fungus *Otthia amica*. The spores of this Otthia measure 26.6–41.8 × 11.4–16.2μ while those of *Otthia amica* measure 22–30 × 11–15μ.

TWO NEW SPECIES OF WASHINGTON FUNGI

The first of these fungi belongs to the group Sphaeropsidales of the Fungi Imperfecti. Upon study of the fungus, it was found to belong to the genus Neottiospora and I propose the following name:

Neottiospora yuccaeafolia n. sp.

Pycnidiis fere hemisphaericis; ostiolo in plan plano latere posito, in folii contextum immerso, 216–324μ; sporulis fere cylindricis, hyalinis, granulosis, 1–4 cilia ad apicem gerentibus, 38–49.4 × 7.6–11.4μ; ciliis 30–35μ longis.

Hab.:—In foliis Yuccae depereuntibus aut mortuis. Pullman, Wash.

Pycnidia hemishaerical with the mouth upon the flat side, immersed in the tissue of the leaf, 216–324μ in diameter. Spores nearly cylindrical, hyaline, with 1–4 cilia at the apex, 38–49.4 × 7.6–11.4μ (fig. 11); cilia 30–38μ in length.

The second of these fungi belongs to the hyphomycetes in the same group as Goniosporium and Arthrinium, but, since these are separated upon the shape of the conidia, I believe that it is necessary to make a new genus of this and on that account propose the following name:

Tureenia juncoidea n. sp.

Hyphis fertilibus, erectis, simplicibus, septatis, hyalinis, anulos ad septa fuscos gerentibus, basidio bulboso; sporulis ex sphorophorae internodiis orientibus, fuscis, naricullariis, appendicula tenuia ad utrumque partem extremum emittentibus; 7.6–9.5 × 15.2–19μ (appendiculis omissis); appendiculis 7.6–11.4μ longis.

Hab.:—In culmis Junci mortuis. Pullman, Wash.

Fertile hyphae erect, unbranched, hyaline with black rings at the septa, and with a bulbous base (fig. 12); spores borne upon the side of the internodes of the sporophore, dark colored, naviculate with slender appendages

at each end, 7.6–9.5 × 15.2–19μ without appendages; appendages 7.6–11.4μ long.

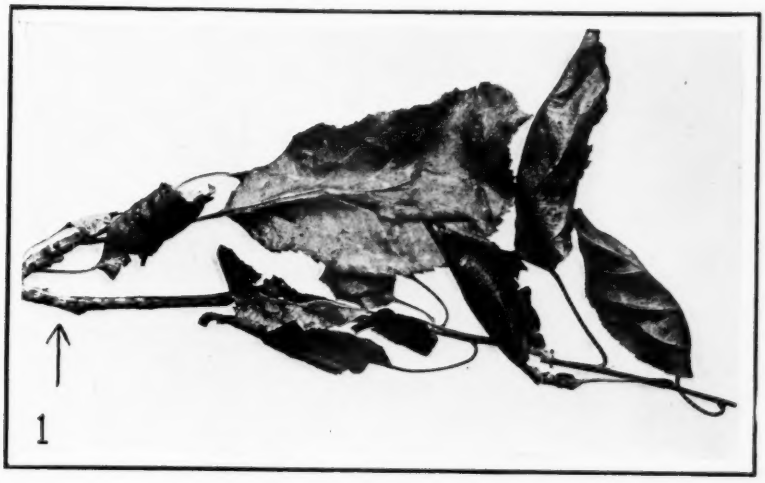
Specimens of these two fungi will be deposited in the cryptogamic herbarium of Harvard University, the New York Botanical Garden, and the Department of Agriculture at Washington, D. C.

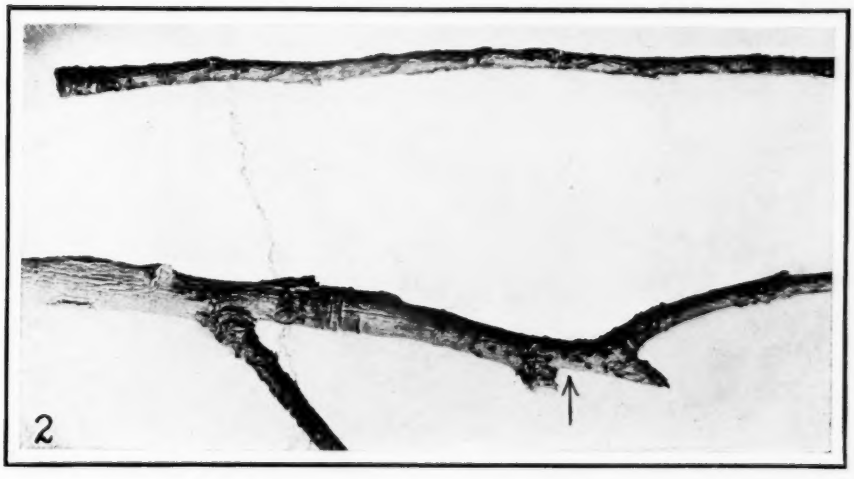
WASHINGTON STATE COLLEGE

EXPLANATION OF PLATE IV

FIG. 1. Twig of Apple showing "Fire-Blight" appearance due to disease.

FIG. 2. Twig of Apple showing epidermis of bark broken by the perithecia In both figures the arrows indicate the points of attack.





HALL: NOTES UPON WASHINGTON FUNGI

Explanation of Plate V

Fig. 3. Ascus of Otthia showing arrangement of spores.

Fig. 4. Ascospores free from the ascus.

Figs. 5, 6. Germinating ascospores.

Fig. 7. Young spores from culture.

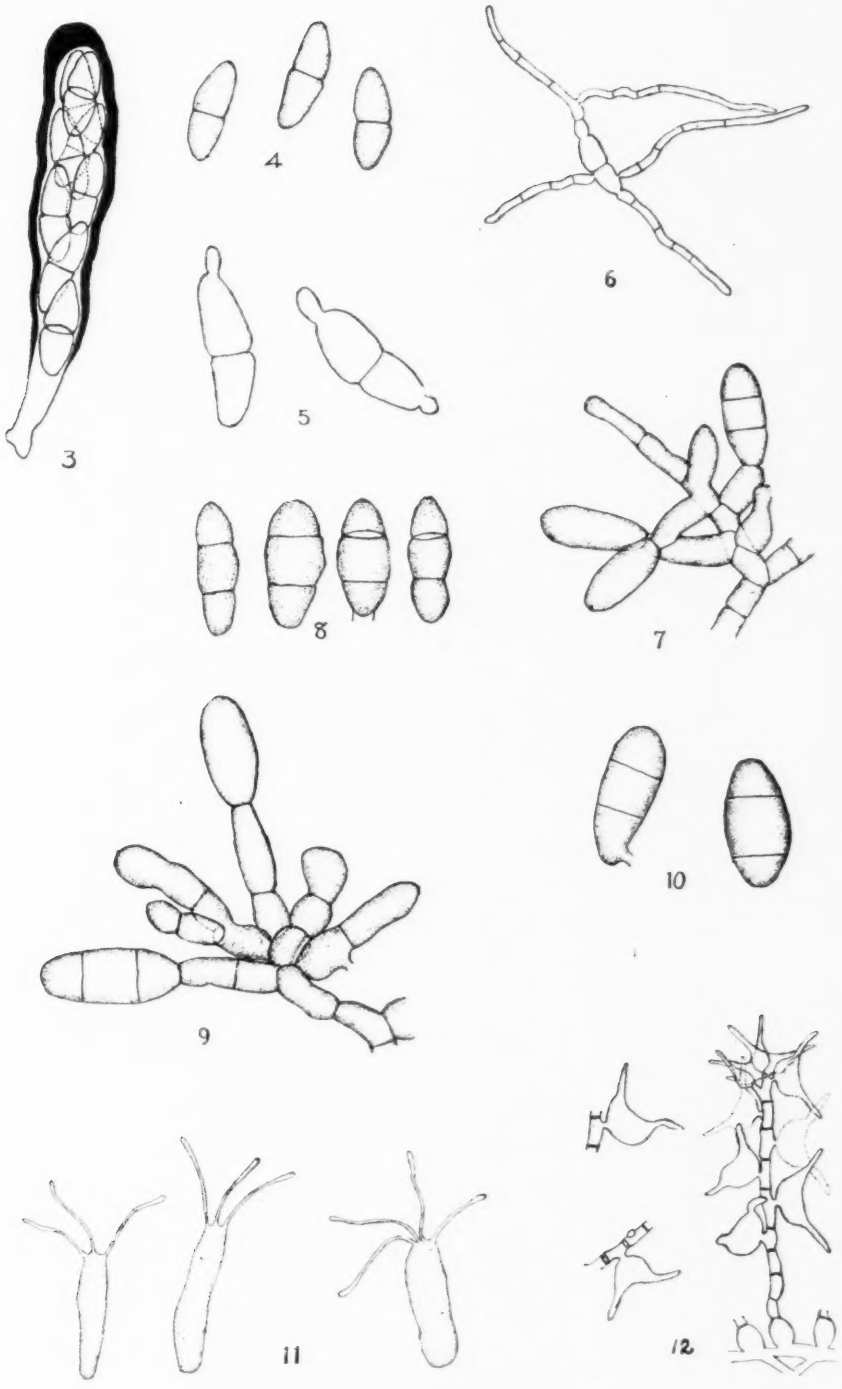
Fig. 8. Mature spores from culture.

Fig. 9. Spores and sporophores from culture showing the beginning of Sporodochia.

Fig. 10. Spores of Coryneum from apple twig.

Fig. 11. Spores of Neottiospora yuccaefolia.

Fig. 12. Fertile hypha of Turcenia juncoidea, with two single spores.



HALL: NOTES UPON WASHINGTON FUNGI

THE RHIZOCTONIA LESIONS ON POTATO STEMS

F. L. Drayton

With Plate VI and One Figure in the Text

Investigators of the Rhizoctonia disease of potatoes, caused by the fungus now referred to as *Corticium vagum* var. *solani* Burt, have referred to the dark brown lesions occurring on the underground main stems and on the tuber-bearing stolons as the most prominent and typical symptoms of the disease. These lesions are irregular in shape, varying in size from the head of a pin to an area of some few centimeters in extent, sunken, dark brown and usually running longitudinally on the stem, but sometimes completely girdling the thinner portions. This injury is so constantly associated with other evidences of Rhizoctonia that it was taken for granted to be due to the parasitic growth of the Rhizoctonia mycelium; but apart from the fact of its association, and the presence of superficial hyphae, I failed to discover any further proof in any of the literature at my disposal.

In the more important investigations, the following statements may be found in connection with stem lesions.[1]

B. M. Duggar and F. C. Stewart in 1901: "The hyphae occur in scab ulcers, those near the surface are brown, while the deeper lying ones are colorless." . . . . "While the Rhizoctonia hyphae may be abundant in scab ulcers, *there is no evidence that they have anything to do with the formation of the ulcers.*"

F. M. Rolfs in 1902: "The wounds below ground are usually characterized by a reddish brown color and vary in size and shape." . . . . "On examining diseased plants, *the parts below ground are thoroughly infected with Rhizoctonia* and often *the pith of the stem* is filled with the fungus."

A. D. Selby in 1903: "The stems below the soil surface showed numerous lesions in the form of brown, dead areas. Microscopic study of the fresh material revealed the *apparently constant presence of the hyphae of the fungus Rhizoctonia.* The lesions are of diverse appearance, commonly having a darker character than the whitened portion of the stem beneath the earth. In advanced stages of the trouble, an oblong "blaze" more than an inch in length may be found along the side of the potato stem."

G. P. Clinton in 1904: "*The mycelium grows out on the young stems and roots.* Sometimes it produces diseased or girdled areas."

[1] In all of these quotations the italics are mine.

G. H. Pethybridge in 1911: "Under certain circumstances, it may prove harmful; *the tips of the young developing sprouts may be killed off by the fungus.*"

W. A. Orton in 1911: "*It may cause lesions* on the potato stem at the soil line and below."

J. G. Hall and F. L. Stevens in 1913: "The black spots appear near the surface of the ground, destroying the bark and often girdling the stem. A dark network of fungus threads *is sometimes seen upon the subterranean parts.* On examining diseased parts, the injury caused by the fungus will frequently be found as a wound, often 2-3 cms. in length, upon the stem at or near the surface of the ground."

W. O. Gloyer in 1913: "The fungus may live as a parasite attacking the stems, stolons or roots of the plants. *At the point of attack, cankers are formed,* which in time may increase so as to girdle the plant or separate portions from the main stem."

F. A. Sirrine in 1914: "This fungus attacks the young sprouts of the seed piece causing the brown cankers on them which frequently kill the sprout."

W. J. Morse and M. Shapovalov in 1914: "The lesions are brown in color and more or less covered *with coarse brownish threads, apparently Rhizoctonia*" . . . . "Brown lesions of various sizes began to appear on the sprouts below ground soon after they started from the seed pieces." . . . . "The brown diseased area may occur anywhere on the part of the stem below ground and extend from the surface inwards."

Later on in their bulletin, page 205, they express their opinion as follows, and this is the most important reference in this connection. "The lesions were dry in nature, and in the more advanced stages, brownish black in color *and more or less covered with Rhizoctonia filaments. The fungus appeared to be entirely superficial. As far as could be judged by microscopical examinations, it did not penetrate beneath the skin to any extent.* Occasionally discoloured streaks following the line of the vascular bundles penetrated the flesh for a short distance, *but no trace of fungus mycelium could be found in them.*"

During the past summer, a great many hills of potatoes in our experimental field plots have shown symptoms of Rhizoctonia injury and particularly the dark brown lesions on the stems below ground (pl. VI, fig. 4) resembling in every respect those described in the above quotations. It was then that I was instructed by Mr. H. T. Güssow, Dominion Botanist, to carefully investigate these lesions microscopically to determine definitely whether, and if so to what extent they were really produced by the mycelium of the Rhizoctonia or whether they were merely lesions of independent origin erroneously associated with other well-known symp-

toms, such as the inward curling of the leaves, the production of sclerotia on the tubers, stems and roots, the failure of diseased hills to produce normal sized potatoes, and the occasional formation of aerial tubers.

The method of procedure adopted in this investigation and the results obtained are as follows: The material was collected during the month of August and a number of lesions of different shapes and sizes were chosen, some of which appeared as longitudinal local lesions, and others almost girdled the small tuber-bearing stems. Short pieces containing diseased areas were cut out, parallel to the surface, parings were made of the lesions on the bigger stems, and some were split in half and cut into short lengths. All of these pieces were fixed in Flemming's solution for six hours, washed thoroughly, dehydrated and embedded in paraffin of melting point 60°C., using chloroform as solvent. Sections varying in thickness from 6 to 10μ, were then cut of this material with a rotary microtome in varying directions, transversely and longitudinally in each piece. They were then fixed on slides, stained with carbol fuchsin, and mounted in Canada balsam in the usual way.

RESULTS

The transverse sections of the parings showed the first indication of internal mycelium. These parings had been cut to the depth of the vascular bundles, and in every case a large number of cells in the cortex, varying from 3 to 6 cells deep from the surface of the lesion, were filled with granular, closely compacted hyphae, which were undoubtedly Rhizoctonia sclerotia-forming hyphae, as shown by the very characteristic short "bloated" cells with constrictions at the cell walls. Surface sections of the parings revealed the same condition, illustrated by a photomicrograph (pl. VI, fig. 1). Further sectioning of the whole and halved stems then revealed the actual penetration of the mycelium (fig. 5). Cells of the cortex, vascular bundles (fig. 2), and pith all were found to be invaded by mycelium, which from transverse and longitudinal sections proved to be that of Rhizoctonia. In the vascular bundles and pith, the compacted masses of hyphae which were found in the cortex were not observed, but, instead, individual hyphae were found running longitudinally and sometimes obliquely in the cells of these tissues and in the intercellular spaces.

As will be seen, the mycelial masses in the cortical cells resemble closely the structure of the so-called Rhizoctonia sclerotia, and they no doubt give the brown color to the lesions, and may well be a means of infecting subsequent crops in the same field if left on or in the ground in the same way that the sclerotia formed on the roots (fig. 3) are a means of reinfecting subsequent crops. This would emphasize the advisability of carefully collecting and burning all plant refuse after harvest, especially when the field was badly diseased.

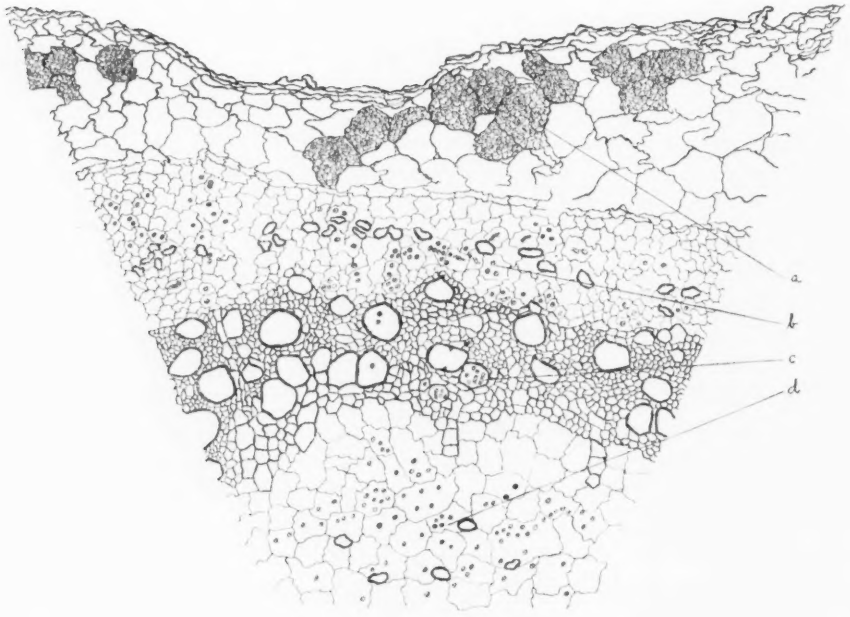


FIG. 5. Cross-section of potato stem showing Rhizoctonia sclerotia in the cortical tissue and mycelium in the vascular bundles and in the pith.

The presence of the mycelium constantly observed in the lesions and the permeation of nearly all tissues by this, leaves little doubt in my mind that Rhizoctonia is the cause of the trouble. The invasion and plugging of the vascular tissues, diverting the food material going from the leaves to the actively growing parts, or stopping it entirely, account for the production of undersized tubers or no tubers at all. Further, the stopping of the upward current by the plugging of the vessels, especially in a dry season, may produce the curling of the leaves, a symptom nearly always associated with this disease. Naturally, sometimes infections may be slight and no leaf curling will have occurred, but the evidence offered is sufficient proof for the stem parasitism of the fungus.

DIVISION OF BOTANY
CENTRAL EXPERIMENTAL FARM, OTTAWA
DOMINION OF CANADA

DRAYTON: RHIZOCTONIA ON POTATO

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NOTES ON CHESTNUT FRUITS INFECTED WITH THE CHESTNUT BLIGHT FUNGUS

CAROLINE RUMBOLD

In order to test certain theories with regard to the infection of chestnut burs and nuts, a large number of fresh sound nuts and of burs containing nuts were collected in a blight-infected chestnut orchard in October of last year (1913). The burs and nuts of individual trees were tied up in fresh paper bags as soon as gathered, treated with carbon disulphide, so as to kill all chestnut worms, and were then placed in a warm, nearly air-tight closet. Here they were in an atmosphere closely resembling that of a damp chamber. The burs and nuts began sweating as soon as gathered and continued to sweat in the closet.

The spores of the chestnut blight fungus which had been deposited on the burs while they were in the orchard quickly developed the characteristic yellow-colored mycelium. In January the nuts were cut open. More than a third of them were found infected with the mycelium of the blight fungus.

The nuts which had remained in the burs formed a large majority of the infected fruits. The burs were the source of infection. The fungus grew from the infected bur through the shell at the base of the nut where there is a close connection between the two and where the hard shell of the nut matures last. Orange colored mycelium showed in patches on the shell around the base of the nuts. Those infected nuts found outside of burs, showed mycelium at their bases, indicating that they had become infected in the burs and had afterward dropped out.

Inside the hard shell of the chestnut uncontaminated growths of the blight fungus were frequently found, although molds, especially *Penicillium* sp., had in some cases penetrated the kernels. Sometimes an aerial mycelium, white or cream-colored, grew around the kernel. At other times very little mycelium showed. The hyphae spread throughout the kernel and could be seen when pieces were put under the microscope. Particles of these kernels laid on nutrient agar quickly produced typical cultures of *Endothia parasitica* (Murr.) A. &. A.

As the mycelium spread through the kernel, the color of the latter changed from a glossy yellow to a dull light gray. In January the healthy nuts were so hard it was difficult to bite into them, while the infected

nuts were much softer and somewhat crumbly. Nuts infected with the chestnut blight are extremely bitter to the taste.

Before the harvest of 1913, blight-infected chestnut burs were observed lying under the trees in the orchard; a few infected nuts were noticed, but no attempt was made to find the percentage of infected nuts. In view of the comparative ease with which the nuts in the burs were infected with the blight fungus, the possibility is strongly suggested that there is more than an occasional infected chestnut among the bags of nuts gathered and sold from the blight infected region.

Blight-infected chestnuts were found by Mr. J. Franklin Collins in 1912, and, in his account,[1] he suggested infected nuts as a possible means of the spread of infection. The facts here stated seem to confirm his suggestion.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
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UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA.

[1] Collins, J. Franklin, Science N. S. **38**: 857–858. 1913. The Chestnut Bark Disease on Chestnut Fruits.

THE KNOWN DISTRIBUTION OF PYTHIACYSTIS CITROPHTHORA AND ITS PROBABLE RELATION TO MAL DI GOMMA OF CITRUS

HOWARD S. FAWCETT

Pythiacystis citrophthora (Sm. and Sm.), the lemon brown rot fungus, was previously reported by the author to be the causal agent in one form of lemon gummosis in California. (PHYTOPATHOLOGY, vol. iii, p. 194, June, 1913, and Monthly Bulletin, California State Commission of Horticulture, Sacramento, vol. ii, pp. 601–617, October, 1913). Since these publications, the fungus has been isolated from diseased bark of many gummosis specimens representing all of the important citrus growing localities of California. Many additional inoculations have also been made, all of which confirm this preliminary report. In June, 1913, *Pythiacystis citrophthora* was also isolated from diseased bark of orange trees that appeared to be affected with typical Mal di gomma, or "foot rot" as it occurs in California. Inoculations with cultures of this fungus in July, 1913, into large crown roots of old orange trees have in nine months developed diseased areas which resemble the beginning stages of Mal di gomma. The orange bark, being somewhat more resistant than lemon bark, reacts differently to the attack of this fungus. This fact appears to explain the difference in the general appearance of Mal di gomma and of lemon gummosis in California.

During a recent trip to Florida, Cuba, and the Isle of Pines, the author isolated *Pythiacystis citrophthora* from trees affected with gum diseases in these three places. In Florida, the fungus was obtained from a typical Mal di gomma or "foot rot" specimen. The specimens in Cuba and Isle of Pines from which the fungus was isolated, appeared to resemble more closely the so-called lemon gummosis of California, although found on pomelo trunks.

Prof. R. E. Smith, of the University of California, on his return from a trip in the citrus districts of Southern Europe, reported that he found lemon fruits affected with *Pythiacystis citrophthora* in Sicily in a grove where foot rot was prevalent, and he felt sure from descriptions given him by growers in Valencia, Spain, that it also occurred on orange fruits there. To quote from a letter recently received from Prof. R. E. Smith: "In Sicily I found lemon fruits affected by typical brown rot (*Pythiacystis citrophthora*) in an unmistakable manner. This was in a low-lying, poorly

drained grove where foot rot (but not gummosis of the trunk) was very prevalent. In Valencia, Spain, I inquired about the matter, describing the effect upon fruit, and was told by the growers that they had on oranges the same thing by the name of 'Aguada,' meaning watery. Their description of this form of decay fitted lemon brown rot exactly, both as to appearance and occurrence."

Pythiacystis citrophthora is reported to occur on lemon fruits in Brazil by R. Averna Sacca in Boletin de Agricultura, 13 Series, March, 1912.

The inoculation experiments so far carried out in California, together with the finding of the fungus in Mal di gomma specimens in Florida, indicate that in addition to being the cause of lemon brown rot and one form of lemon gummosis, *Pythiacystis citrophthora* may also be at least one of the causal agents in the occurrence of Mal di gomma.

Further experiments are being carried out to determine definitely, if possible, what relation *Pythiacystis citrophthora* may have to Mal di gomma.

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LINDNER'S ROLL TUBE METHOD OF SEPARATION CULTURES

A. F. Blakeslee

With Plate VII

At the Atlanta meeting of the Phytopathological Society, the writer demonstrated an improved method which he had devised and used the year previous for making separation cultures. Since that time he has discovered that the same method had been in use and previously noted by P. Lindner.[1] Since the method is not familiar to the mycologists of this country who have been consulted, and, inasmuch as Lindner's original account is in a brewery journal presumably not accessible to all the readers of this journal, it has seemed desirable to add a note at this place on the subject.

The method is a modification of the Esmarch roll tube method and consists essentially in the substitution of cylindrical specimen jars of quart and half gallon capacity for the ordinary Petri dish. These tubes are plugged and kept upright as shown in plate VII. They are made by Whitall Tatum Co. Jars with a neck apparently better adapted for the cotton plugs are reported by Lindner as sold by the Vereinigten Lausitzer Glaswerken. The advantages of this method over that employed with plates or Petri dishes are the larger number of colonies that can be isolated from a single pouring and the relative freedom from contamination during the operation and later growth. The size of the specimen jars gives the taller molds room for full aerial development, not possible in a Petri dish. A Petri dish sucks in air while the medium is cooling and, with changes of temperature throughout its use, may be pumping in foreign germs. Further, when an inoculation is made from a Petri dish, the cover must be raised and danger of contamination again occurs. The cotton plug in the cylindrical tubes makes these jars as secure from infection as a plugged test tube.

For molds, agar alone has been preferred by the writer and this of course must be filtered or cleared by centrifuging. Tubes previously plugged and sterilized are warmed in a Bunsen flame before using. The tube with the liquid agar is held horizontally under a tap of cold water and rotated on its long axis at the same time that it is jerked vigorously from right to left to prevent the wave of thickening agar from being irregularly dis-

[1] Wochenschrift für Brauerei **29**: 589–590. October 12, 1912.

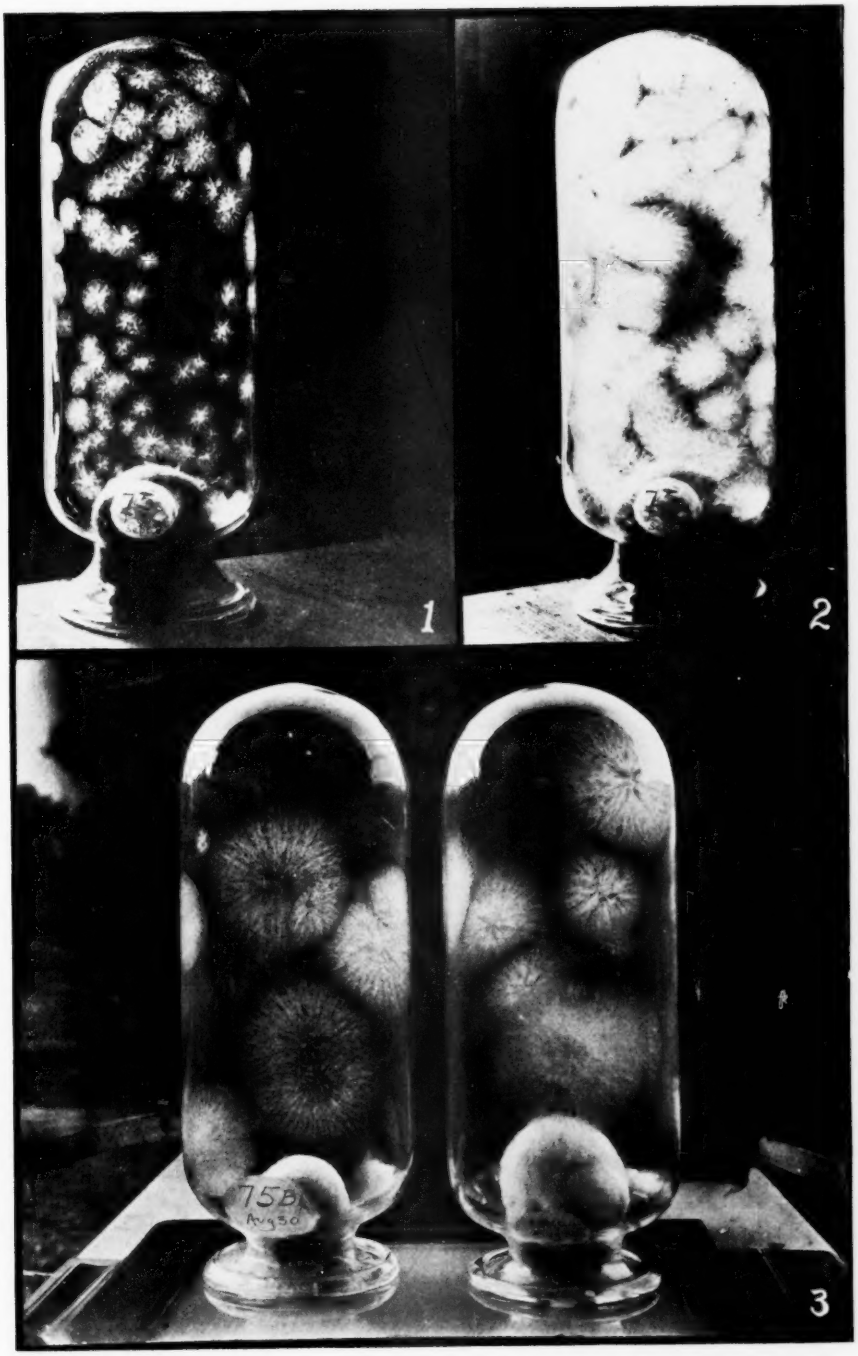
tributed. The tube must be thoroughly cooled or the thin layer of agar will crack upon standing. Usually the first tube is allowed to lie horizontally under a tap or in ice water to finish its cooling while the second tube is being turned and shaken. Water from a tap has been found more effective for the initial cooling than ice, snow, or ice water. If the tubes are stored in an erect position, the cotton plug will absorb the liquid which squeezes out of the agar. The proper thickness of the agar layer on the inside of the tube will depend upon the size of the tube and upon the concentration of agar used in the nutrient. From among a large number of combinations tested by the writer, the following formula has been found most convenient and valuable for the mucors and has been adopted as a standard for this group.

	per cent
Agar flour	1.8 to 2.0
Dry malt extract	2.0
Dextrose	2.0
Meat peptone	0.1

CONNECTICUT AGRICULTURAL COLLEGE
STORRS, CONN.

EXPLANATION OF PLATE VII

FIG. 1. Separation culture of a mucor, 3 days old.
FIG. 2. The same as figure 1, 5 days old.
FIG. 3. Two culture jars showing relatively few mature colonies.



BLAKESLEE: LINDNER'S ROLL TUBE METHOD

PHYTOPATHOLOGICAL NOTES

New hosts for some forest tree fungi. During a recent collecting trip on the headwaters of the main North Fork of Clearwater River, St. Joe National Forest, Idaho, some very interesting new hosts for some common forest tree fungi were studied. Specimens of these fungi are deposited in the collections for study in the Laboratory of Forest Pathology, at Missoula, Montana. The most important new hosts found on this excursion are as follows:

Herpotrichia nigra Hartig, or its related form or species, *Neopeckia coulteri* (Pk.) Sacc., on *Thuja plicata* (giant western red cedar), *Abies grandis* (grand fir), *Taxus brevifolia* (western yew), and *Pseudotsuga taxifolia* (red or Douglas fir). The fungus has been observed to spread to various herbaceous and heather-like plants when in contact with the coniferous host. The common mountain heather, *Phyllodoce emptriformis*, is very frequently so infected.

On hosts previously reported the fungus was surprisingly abundant, particularly in the region around the Monumental Buttes. The leaders of *Pinus monticola* (western white pine) are frequently attacked and killed and at such low elevations that the fungus may be considered of great economic importance. In the same locality at higher elevations *Picea engelmanni* (Engelmann spruce), *Tsuga mertensiana* (mountain hemlock), *Pinus contorta* (lodgepole pine), *Pinus albicaulis* (white barked pine), and *Abies lasiocarpa* (alpine fir) are universally infected. In many cases this results in the entire destruction, or thinning out, of stands composed of these species.

Fomes laricis Fr. is here reported for the first time on living *Pinus monticola, Abies grandis* and *Tsuga mertensiana. Fomes igniarius* (L.) Gillet was found on living *Rhamnus purshiana* (shittimwood) and *Sambucus glauca* (elderberry). Dead wood in wounds on the former host species was, in two cases, infected by *Coniophora olivacea* (Fr.) Bres., a very unusual habitat for such a pronounced saprophytic fungus, which usually occurs on dead western white pine.

Aside from a very serious and undetermined needle disease which attacks the species, *Taxus brevifolia* is probably more immune from fungous attack than any other conifer. It was with much surprise that *Armillaria mellea* (Vahl.) Quel. was collected from this tree. A larger tree, presumably of great age, exhibited a brown friable heart rot breaking up in

cubes. A small sporophore of *Polyporus schweinitzii* Fr. growing at the base of the tree seemed responsible for the rot.

Polyporus lucidus Leysser (Ganoderma) growing on the roots of a living mountain hemlock at 6000 feet elevation was another interesting collection. The mountain hemlock, which attains a fine merchantable size in these regions, was in many places seriously suppressed by *Razoumofskya tsugensis* Rosend. *Echinodontium tinctorium* E. & E. was abundant on this hemlock. One collection of this fungus was made from the Engelmann spruce, a very rare and unusual host.

JAMES R. WEIR

The potato scab organism. Güssow[1] has proposed the name *Actinomyces scabies* for the organism which causes common potato scab and which has been known in the past as *Oospora scabies* Thaxter. Still more recently Lutman and Cunningham[2] have stated that in cultural characters it is identical with *A. chromogenus* Gasperini and should be known under that name. In this connection it is of interest to note the opinion expressed by Jaczewski[3] in 1910 as shown by the following translation:

"*Oospora scabies* and other related species, isolated by Krüger from beets affected with scab are not true fungi and cannot be included in the genus Oospora as characterized by Saccardo for certain Hyphomycetes. These organisms are allied to bacteria and are identical with the forms Actinomyces, causing a disease in plant and animal tissues known as Actinomycosis."

M. SHAPOVALOV

The citrus-root nematode (Tylenchulus semipenetrans) in Florida. Until recently the citrus-root nematode, *Tylenchulus semipenetrans* Cobb, has been reported from only one locality in Florida (Cobb, N. A., Journ. Agr. Res., Vol. II, No. 3, June 15, 1914). Thomas (Cir. 85 Univ. Cal.) states that it may be an important factor in the growth of the citrus trees in California and brings out the apparent close connection of "mottled leaf" (a form of chlorosis) and the nematode. In August 1914, the writer found it in the experiment plots of the Florida Agricultural Experiment Station at Gainesville, where a survey of the grounds for this nematode was being made.

[1] Güssow, H. T. The systematic position of the organism of the common potato scab. Science **39:** 431-432. 1914.

[2] Lutman, B. F. and Cunningham, G. C. Potato scab. Vt. Agl. Exp. Sta. Bul. 184. 1914.

[3] Jaczewski, A. A. Bu. Myc. and Phytopath. Rep. 6, **1910:** 128. St. Petersburg. 1912.

Thirty-five orange trees were examined. Five of these trees had healthy foliage, and showed no infestation with nematodes. The leaves of the remaining thirty were affected with "frenching" (a form of chlorosis). Twelve of the thirty frenched trees were infested with the root nematodes, but the remaining eighteen frenched trees showed no infestation. Most of the infested trees were examined two or more times. The infested and uninfested trees were growing in the same plot and often in the same row, sometimes only twenty feet apart.

Further investigations and experiments are necessary before any final conclusions as to the connection of this nematode with frenching can be drawn.

EDGAR NELSON

A new host for a species of Razoumofskya. From all published lists of the various hosts of the genus Razoumofskya, one western conifer is conspicuously absent. This is *Pinus albicaulis*, the white bark pine. It is here reported for the first time as a host for one of the several species of mistletoe common on conifers in the West. The first specimen to reach the Missoula Laboratory was collected by Mr. E. E. Hubert, at Wise River, Montana. The second collection made by the writer in the region of the Deerlodge Valley, Montana, is identically the same plant as that collected by Mr. Hubert, except it is more branched and robust. The plant may be tentatively referred to the species *Razoumofskya cyanocarpa* Nelson. The parasite causes the formation of small compact brooms and considerable hypertrophy of the infected stems.

JAMES R. WEIR

Notes on Rhizoctonia. At a coniferous nursery in the sand-hills near Garden City, Kansas, the writers have found Rhizoctonia to be very commonly present in damped-off pine seedlings, apparently having been the chief cause of loss in beds of *Pinus ponderosa* during the present season. Parasitic strains often begin work in the beds before the seedlings come up. The result is that over areas sometimes two feet in diameter no seedlings appear above ground. The parasite continues to spread for six or eight weeks after germination of the pines, causing the damping-off of all pine seedlings within four to eight inches of the edge of the bare area, and of the younger seedlings farther back from the edge. Rhizoctonia appears to produce larger single patches of dead seedlings than any other damping-off organism in western nurseries, and to attack seedlings too old to be killed by *Pythium debaryanum* or *Fusarium moniliforme*.

Of the weeds most commonly present in the seedbeds, the Russian thistle seems to be the only one regularly capable of coming up in areas

where the appearance of pine seedlings is prevented by Rhizoctonia. Seedlings of *Ambrosia psilostachya, Chenopodium leptophyllum, Helianthus* sp., and other dicotyledons are found damped off in areas in which the pines are being killed by Rhizoctonia. Examination of the soil in the neighboring sand-hills shows Rhizoctonia very commonly present in groups of *A. psilostachya*. In some of these groups, underground roots are found to be parasitized to a considerable extent by the Rhizoctonia, very definite killed portions covered with hyphae being found in otherwise healthy roots. In such parasitized groups many of the tender shoots sent up from underground roots in the spring are killed before they reach the soil surface, the condition of the stems attacked strongly resembling the condition of the underground portions of the hypocotyls of damped-off seedlings. Only occasional groups of the ragweed are parasitized in this way, indicating either variation in resistance between different groups, or, as seems more probable, differences in virulence in different strains of the parasite. Pine seedbeds on new soil, where such parasitized groups of ragweed had been previously located, have suffered especially from damping-off. Because of the perennial habit of this ragweed it is an ideal host for parasitic strains of Rhizoctonia to winter on, and it is suggested that this weed be eliminated as far as possible from soil used for crops susceptible to Rhizoctonia injury.

CARL HARTLEY
S. C. BRUNER

Chestnut blight in Nebraska. Specimens of the chestnut bark fungus *Endothia parasitica* (Murr.) And. were collected at two places in Nebraska in September and October, 1914.

On a small grafted Paragon chestnut in the University of Nebraska forest plantation, Lincoln, Nebraska, the disease was found to have girdled the main stem of a tree which was nine-sixteenths of an inch in diameter, but there were still some green leaves above the point of girdling. This tree was one of about 600 shipped from a nursery at Paxinos, Pennsylvania, to a Nebraska nursery in the fall of 1913. Two trees only of the 600 were shipped to Lincoln on April 7, 1914. The other tree was examined but no evidence of the chestnut blight was found.

A lot of 50 or 60 chestnut trees of this same shipment which still remained at the nursery in Beatrice, Nebraska, were examined in October, 1914, and the chestnut bark disease was found on one of them.

While chestnut is not native in Nebraska, the growing of chestnut trees for their nuts is beginning in this state. It is, therefore, of importance that this disease be kept out and therefore that only clean stock be received.

ROY G. PIERCE

Personals. Dr. Arthur Harmount Graves has resigned his position as Assistant Professor of Botany in the Sheffield Scientific School of Yale University, and is at present engaged in research at the laboratory of Prof. V. H. Blackman, Professor of Plant Physiology and Pathology at the Royal College of Science, South Kensington, London, England. Dr. Graves has been a member of the Yale faculty for the past twelve years. His present address is care of Brown, Shipley and Company, 123 Pall Mall, London, England.

Geh. Reg. Rat. Dr. Otto Appel, of the Kaiserliche Biologische Anstalt, of Dahlem-Berlin, has been in the United States since July 15, 1914, to study phytopathological conditions here, as the guest of the United States Department of Agriculture, and some of the leading universities mentioned below.

On July 20–22 he delivered three addresses before the Graduate School of Agriculture, at Columbia, Missouri, on Breeding Disease Resistant Plants and on Diseases of Cereals. On July 27–October 3, he participated in a "potato study trip" made by Department of Agriculture and Experiment Station workers through the principal northern potato sections, from New Jersey and Maine to California, planned with especial reference to potato improvement through control of diseases and official seed inspection and certification.

He has since delivered the following lectures:

At the University of California, Berkeley: 1. The Scientific Fundamentals of Phytopathology; 2. The Breeding of Disease Resistant Plants.

At the 25th Anniversary of the Missouri Botanical Garden, St. Louis, The Relations between Scientific Botany and Plant Pathology.

At the Iowa Agricultural College, Ames, on: 1. The Breeding of Disease Resistant Plants; 2. The Leaf Roll Disease of the Potato.

At the University of Minnesota, University of Wisconsin, and Cornell University, on The Breeding of Disease Resistant Plants and on Potato Diseases.

Dr. Appel will remain in Washington until further notice, pending arrangements for his safe return to Germany.

Dr. Johanna Westerdijk, Director of the Willie Commelin Scholten Phytopathological Laboratory, in Amsterdam, Holland, who has been in the United States since August 12, sailed for home via Genoa, on December 3.

Dr. Westerdijk came first to San Francisco from a year spent principally in Java and Sumatra to investigate plant diseases in the East Indian colonies of the Netherlands. She accompanied the potato study party through Michigan, Wisconsin, and Minnesota, and from Spokane, Washington, to California, later visiting southern California, St. Paul, Madison

and Washington, D. C. She also attended the anniversary celebration of the Missouri Botanical Garden at St. Louis and delivered a lecture on The Plant Diseases of the Dutch East Indies at the University of Wisconsin and a series of lectures on plant diseases at the University of Illinois.

P. J. O'Gara resigned as pathologist and entomologist for the Rogue River Valley, Oregon, on March 1, 1914, having accepted the position of chief in charge of the Department of Agricultural Investigations for the American Smelting and Refining Company with headquarters at Salt Lake City, Utah.

Dr. G. W. Keitt, formerly scientific assistant in fruit disease investigations, Bureau of Plant Industry, has resigned to accept an appointment as assistant professor in the Department of Plant Pathology of the University of Wisconsin.

Mr. F. V. Rand, scientific assistant in fruit disease investigations, has been transferred to the Laboratory of Plant Pathology, Bureau of Plant Industry. He is succeeded by Mr. L. M. Hutchins, formerly an assistant in the forage plant breeding work of the Bureau.

Mr. R. B. Wilcox has been appointed scientific assistant in the Bureau of Plant Industry, to conduct investigations on the diseases of small fruits.

Dr. E. M. Harvey, of the University of Chicago, has been appointed scientific assistant in the Bureau of Plant Industry, to investigate physiological fruit diseases, and is stationed at Watsonville, California.

Prof. L. H. Pennington has been appointed forest pathologist and professor of forest botany in the New York State College of Forestry, Syracuse, New York.

Mr. Guy West Wilson, recently agent in the Office of Forest Pathology of the United States Department of Agriculture, with headquarters at New Brunswick, New Jersey, has been appointed to the chair of mycology and plant pathology in the State University of Iowa.

Mr. George H. Chapman, assistant botanist of the Massachusetts Agricultural Experiment Station, has returned to his post after a year's leave of absence spent at the University of Prague.

Mr. A. Vincent Osmun has been promoted to the rank of associate professor, and Mr. F. A. McLaughlin to that of instructor, in the Department of Botany at the Massachusetts Agricultural College.

Dr. M. P. Henderson, recently fellow in Plant Pathology at the University of Wisconsin, has accepted a position as Plant Pathologist in the Oregon Agricultural College, in charge of the work in Phytopathology at Medford.

Bacteria in relation to plant diseases. Smith, Erwin F. Vol. 3, Quarto; pp. i–vii, 309; 155 text figures, 47 plates, including 4 lithographs in color. Carnegie Institution, Washington. Publication No. 27. Distributed August 7, 1914. Price, $5.

This is the third volume in the monumental task which the author has set himself. It is perhaps commendation enough to say that it maintains the high standards of the second volume. Following the original outline this is wholly given to Vascular Diseases (Continued). The painstaking detail of treatment is exemplified by the fact that 147 pages are given to the two related diseases, Cobb's disease of sugar cane (*Bact. vascularum*) and Stewart's disease of corn (*Bact. stewarti*). Moreover much of this space is occupied with the discussion of inoculations and other experimental studies carried out by the author extending over the last twelve or more years. Among the matters having both scientific and practical interest, may be mentioned under the first disease the observation upon susceptible and resistant varieties of cane. It is encouraging to learn that there is a marked difference in this respect, certain varieties being highly resistant and others very susceptible. This evidence suggests that resistance may be associated with acidity. "The acidity of the cane juice explains, furthermore, to the writer at least, why the bacteria tend to avoid the parenchyma and inhabit by preference the vascular system the juices of which are only slightly acid or neutral." Striking facts are brought out both under Cobb's disease and Stewart's disease going to show that general infection of the plant is largely dependent on rapid growth following inoculation.

Brown rot of the Solanaceae is given about 100 pages. This closes with an appendix giving a critical summary of the recorded observations of writers on bacterial diseases of the potato and tobacco from various other countries. Owing to the numerous scattered and fragmentary publications which are filling foreign literature relative to so-called bacterial diseases of the potato, and the fact that any such might be borne on imported tubers, this part is of value economically as well as scientifically. The conclusion seems justified that, while it is probable that *Bacillus solanacearum* is an almost world-wide parasite upon potatoes, there is, in most cases of potato diseases attributed to bacteria, insufficient or inaccurate data for satisfactory determination of the causal organism.

In view of the difficulty of controlling bacterial diseases it is noteworthy that the author shows that *B. solanacearum* undergoes rapid loss of virulence both on media and in certain soils which fact may offer a way of attack.

Schuster's work upon his German potato rot (*Bacillus xanthoclorum*) is critically reviewed and the author repeated much of it with the conclusion that "the subject is left in such shape that some careful bacteriologist should repeat all of Schuster's experiments, and make others; only in this way shall we finally come to know what weight to give his statements."

The brief accounts of the two Aplanobacter diseases will be especially welcomed by pathologists. These are Ráthay's disease of orchard grass, *A. rathayi* and the Grand Rapids tomato disease (why so awkward a name, Michigan disease would seem more logical) *A. michiganense*. The former is described as a strikingly conspicuous slime disease thus far found only in Austria and Denmark but which is carried on the seed and may be expected in the United States, especially in the cooler, moister regions, e.g., northern New England, or the Puget Sound regions. The extreme brevity of the account of the gross characters or visible signs of the above tomato disease is, however, disappointing, considering that it is believed to be of much economic importance.

In addition there are brief accounts of other diseases including *Bacterium* (Pseudomonas) *amaranthi* n. sp., Spieckermann's potato disease, Rorer's Trinidad disease of banana (*Bacillus musae*) Briosi and Pavarino's Italian disease of stock (*Bact. matthiolae*), and Berthet's Brazilian disease of manihot (*Bacillus manihotus*).

The plate work is excellent including the colored plates which enrich the volume. The text illustrations are as heretofore deserving of especial note. In almost every case these are original and from drawings prepared under the author's critical supervision. For example one may refer to figures 47 and 48 showing how *Bact. stewarti* is carried in the seed. The bibliographies are full and accurate as heretofore and the index is commendably detailed.

It is gratifying to find in the text, intimation (p. 207) that the manuscript of volume 4 is in preparation and will include some of the parenchyma diseases. Evidently several more volumes are to be expected.

The profession is again indebted not only to the high ideals and devotion of the author, but to the generous attitude of the management both of the United States Department of Agriculture and of the Carnegie Institution, which in combination make possible the production of a work of such magnitude.

L. R. JONES

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

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[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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